THE STORAGE OF NEWLY LEARNED INFORMATION IN SEMANTIC MEMORY

CHRIS SCHRIJNEMAKERS

The Storage of Newly Learned Information in Semantic Memory

Omslag: Dionne de Vrede

CIP-DATA KONINKLIJKE BIBLIOTHEEK, DEN HAAG

Schrijnemakers, Jozef Maria Christian

The storage of newly learned information in semantic memory/
Jozef Maria Christian Schrijnemakers. - [S.l. : s.n.]. - Ill.
Thesis Nijmegen. - With ref.
ISBN 90-9007443-0
Subject headings: semantic memory / learning.

The Storage of Newly Learned Information in Semantic Memory

Een wetenschappelijke proeve
op het gebied van de Sociale Wetenschappen

PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Katholieke Universiteit Nijmegen,
volgens besluit van het College van Decanen
in het openbaar te verdedigen op
woensdag 7 september 1994
des namiddags te 1.30 uur precies

door

Jozef Maria Christian Schrijnemakers

geboren op 21 oktober 1961 te Maastricht

NICI
Nijmeegs Instituut voor Cognitie en Informatie

Promotores: Prof. Dr. J.G.W. Raaijmakers (UvA)
Prof. Dr. E.E.Ch.I. Roskam

Aan mijn ouders

DANKWOORD

Het onderzoek dat in dit proefschrift staat beschreven is mede tot stand gekomen dankzij de samenwerking, voor mij van onschatbare waarde, met een aantal mensen. Op deze plaats wil ik dan ook de gelegenheid te baat nemen om een dankwoord aan hen te richten.

Op de eerste plaats wil ik Jeroen Raaijmakers bedanken die eerst als begeleider, maar later ook als promotor, mijn werkzaamheden altijd nauwkeurig op de voet gevolgd heeft, en mij ook weer op het rechte spoor zette als dat nodig bleek. De discussies met hem, niet enkel toegespitst op het millimeterwerk van het onderzoek, maar ook uitweidend naar de bredere gebieden der geheugenpsychologie, zijn voor mij altijd een stimulans geweest.

Mijn dank gaat ook uit naar Eddy Roskam die, als promotor op de achtergrond vanwege geografische omstandigheden, het proefschrift aan een kritische blik onderworpen heeft toen het zijn uiteindelijke vorm begon te krijgen.

Het was voor mij een genoegen om ruim vier jaar als gastmedewerker aan het Instituut voor Zintuigfysiologie TNO te Soesterberg verbonden te zijn geweest. Het instituut heeft altijd uitstekende faciliteiten geboden voor de uitvoering van mijn onderzoek. Er heerste een prettige werksfeer, waarbij ik tijdens colloquia en werkbesprekingen altijd kon rekenen op belangstelling voor mijn onderzoek van mijn 'op toepassing gerichte' collega's. Prettig was ook onze gezamenlijke vrije tijd, waarbij vooral het lunchpauzevolleyballen (de Cogneuten vs. de Thermo's) en het loopgebeuren hoogtepunten vormden.

Bij het NICI en in het bijzonder de vakgroep Mathematische Psychologie te Nijmegen ben ik altijd welkom geweest. Ik kon er altijd een beroep doen op de interesse en ondersteuning van mijn collega's aldaar.

René Zeelenberg ('preiming') heeft eerst als stagiaire en later als ROAGer een belangrijke bijdrage geleverd aan het programmeren en uitvoeren van een aantal experimenten. Echter, dat niet alleen, hij was ook een ideale discussiepartner wat betreft de broodnodige reflectie op het onderzoek (en andere interessante onderwerpen zoals Blackjack).

, Dank ben ik ook verschuldigd aan een aantal mensen die tijdens de loopperiode van het onderzoek hun technische danwel personele ondersteuning hebben verleend bij de uitvoering van de experimenten. Dit waren met name Joep Mathijssen en dhr. Spiekman (beiden te Soesterberg), en de stagiaires Monika Király en Misja Schreuder Peters (beiden te Nijmegen).

Graag wil ik de Faculteit der Sociale Wetenschappen van de Rijks Universiteit Leiden bedanken voor de geboden faciliteiten, waardoor het mogelijk werd om een van de experimenten uit te voeren.

Op deze plaats ook een dankwoord aan de familie Bouchoms voor het tijdelijk beschikbaar stellen van opa's huis als geïmproviseerd PsyLab, waar ik ongestoord mijn tweede experiment kon uitvoeren.

Last but not least ben ik Prof. Dr. A. Thomassen, Dr. A. De Groot en Dr. A. Dijkstra zeer erkentelijk voor hun deskundige beoordeling van het manuscript.

Table of contents

CHAPTER 1

A PARADIGM FOR INVESTIGATING EPISODIC AND SEMANTIC COMPONENTS IN ASSOCIATIVE LEARNING

1.1. Introduction

The main question of this thesis is under which conditions new information is stored in semantic memory. More specifically, experiments will be reported in which we investigate whether there are sufficient learning conditions for the addition of newly learned associations to semantic memory.

Beginning with the writings of James (1890), several theorists (e.g., Bergson, 1911; Furlong, 1951 and Reiff & Scheerer, 1956 in Tulving, 1983) have speculated about two qualitatively different aspects of human memory, namely the difference between what a person *remembers* about the past and what a person *knows* about the world. Remembering is retrieving what you have experienced earlier at some specified time and place, and it is an act that is highly personal and subjective. On the other hand, knowing is an act of retrieving factual information without any feeling of where and when this information was gained.

These early suggestions about the acts of remembering and knowing led Tulving (1972, 1983) to the idea that each act is associated to a functionally distinctive memory system, episodic and semantic memory, respectively. He provided an extensive taxonomy with diagnostic features specifying the kind of information and kind of operations that are characteristic of both memory systems. Since Tulving, the theoretical concepts of episodic and semantic memory have become a popular theme in the field of human memory which resulted in a large number of experimental investigations.

In this chapter we will first give a short description of the concepts of episodic and semantic memory with an emphasis on the role of contextual information and speed of retrieval in both memory systems. We illustrate our descriptions with the types of associations that are represented in both memory systems. Then, given the theory about episodic and semantic memory, we define a problem that has received little attention until recently (Dagenbach, Horst & Carr, 1990). Most investigators have mainly concentrated on the question whether it can be empirically shown if there is a distinction between episodic and semantic memory. However, another interesting and relevant question is under what conditions information is stored in semantic memory. Based on the work of Salasoo, Shiffrin and Feustel (1985), who have shown how new word codes are formed in semantic memory, we next derive a paradigm in which it can be investigated how newly learned associations are added to semantic memory. The assumptions underlying this paradigm are that a minimal number of (episodic) learning experiences are necessary for semantic learning and that episodic and semantic memory are two interacting components in a larger memory system. Then, in the last part of this chapter we will describe our paradigm. Word pairs are repeatedly presented as prime-target pairs in two semantic memory tasks: Lexical decision and perceptual identification. There are three types of prime-target pairs and these are respectively semantically related, semantically unrelated and neutral. In accordance with the role of contextual information and speed of retrieval that we defined for episodic and semantic memory, we then show the effects that can be expected in our paradigm.

1.2. Characteristics of episodic and semantic memory

In 1972 Tulving published a short essay in which he proposed a functional distinction between episodic and semantic memory (Tulving, 1972, 1983). His proposal entailed that long-term memory consists of two independent components that differ in the type of information that is represented, and in the processes of how the information is stored and retrieved. The units of episodic memory are episodes or events and these contain information about some specific experience together with information about the circumstances or context in which the experience took place. In order to retrieve an episode (i.e., the act of remembering) it is necessary to reinstate the context during which the episode was stored. The units of semantic memory are ideas, concepts and word meanings that represent common knowledge. In contrast to episodes, the units of semantic memory do not contain any information about where and when they were encoded, i.e. the units are decontextualized. Retrieval in semantic memory is assumed to be a process of unpacking or unfolding, meaning that the process is primarily directed by the nature of the stored information.

1.2.1. Episodic and semantic associations

The difference between both memory systems is best illustrated as to the type of associations that are represented in them. In semantic memory associations represent the overlap in meanings between knowledge units such as words, ideas or concepts. The word pairs *tiger-lion* and *silver-gold* are examples of such semantic associations. It is assumed that the more overlap there is in meaning between units, the stronger the association. The semantic association between the category name *bird* and exemplar *robin* is stronger than the semantic association between *bird* and *chicken*. It is further assumed that a semantic association is generic. This means that the association has become detached from the context in which it was attained. The main characteristic of episodic associations is that they represent the co-occurrence of units, words or concepts, in some specified context.

Semantic and episodic associations have been used as stimulus material in many experiments, and mostly other terms have been employed to refer to both types of associations. Semantic associations are usually named preexperimental associations, because they were already learned before they were presented as stimulus material in an experiment. Episodic associations are usually named paired-associates, meaning that a subject learned that during the experiment two words co-occurred together. A paired-associate then refers to the fact that word 1 preceded word 2, or that word 1 was shown to the left and word 2 to the right in some specific experiment.

1.2.2. Episodic and semantic memory tasks

Memory tasks in laboratory can be categorized as episodic or semantic depending on whether they reflect the acts of remembering or knowing respectively. A memory task is classified as episodic:'...if successful performance on the task is not possible in the absence of retained information from a particular episode' (Tulving, p. 55, 1983). Examples of episodic memory tasks are recognition, when the subject has to identify a word as being studied, or recall, when the subject has to reproduce the word. Because an experimenter is interested in how many words are remembered, usually the dependent variable in episodic memory tasks is the proportion correctly identified words. However, in recognition a subject sometimes has to identify as fast as possible whether a word was studied, and consequently the dependent variable is reaction time. Remembrance of episodic associations is usually tested in paired-associate or cued recall tasks. In these tasks the subject has to recognize or recall words with the help of experimenter provided cue words, these being the words that were paired with the to-be-remembered words.

A memory task is classified as semantic if the performance is only dependent on the utilization of knowledge units. Semantic memory tasks are typically those where the subject has to identify or produce words or to verify whether a sentence contains semantic information that is either true ('a robin is a bird') or false ('a donkey has wings'). Usually a subject is instructed to perform a semantic task as fast as possible and consequently the dependent variable will be reaction time. Knowledge of semantic associations is usually tested by presenting word pairs as prime-target pairs in tasks where the processing of the target word is facilitated by the presentation of the prime word. The best known and most widely used of these tasks is the lexical decision task. In this task the subject is presented with a string of letters (the target), and has to decide as fast and as accurately as possible whether it forms a word or not, by responding with a correct keypress indicating 'word' or 'nonword'. Responding to a target is typically faster and more accurate if it is preceded by another word (the prime), that is semantically related, than a word that is semantically unrelated. Thus lexical decisions are faster and more accurate in case of the prime-target pair *tiger-lion* than in the case of the prime-target pair *anvil-bird*. This effect is called the semantic priming effect (Meyer & Schvaneveldt, 1971) and it reflects the knowledge of a semantic relationship between words or concepts. Semantic priming has also been demonstrated in the perceptual identification task. Evett and Humphreys (1981) used a four-field masking procedure, in which the presentation of a consecutive prime and target word was preceded and followed by a pattern mask, so the presentation sequence was MASK - PRIME - TARGET - MASK. Exposure time of the prime and target was at threshold duration. Subjects were instructed to identify any words they thought were present in the display. Evett and Humphreys found that the identification of the target word was facilitated if it was preceded by a semantically related prime.

We have now reviewed some of the basic features of episodic and semantic memory. A complete overview of all the 28 diagnostic features that were formulated for a taxonomy of both memory systems is given by Tulving (1983). However, there are two features, context-dependency and speed of retrieval, that need special attention, because they provide us with hypotheses concerning the addition of newly learned associations to semantic memory. We proceed with a discussion of these features.

1.3. Context-dependency and speed of retrieval

It is generally agreed upon that one important feature that defines the distinction between episodic and semantic memory is whether the information that is stored is context-dependent or not (Hintzman, 1986; Dosher & Rosedale, 1991; Carr, Dagenbach, VanWieren, Radvansky, Alejano & Brown, in press). It is assumed that the information in episodic memory is stored together with contextual elements (Mensink & Raaijmakers, 1988, 1989). These are elements referring to the circumstances, i.e. the time and place, during which the information was added to episodic memory. Retrieval of information from episodic memory is guided by these contextual elements. The elements are assembled into a cue set, and with the help of this set an episode can be searched for, first by sampling the episode and then by recovering the information that is contained in it (see Raaijmakers & Shiffrin, 1981a, and Raaijmakers, 1993, for how such a cue-dependent retrieval process in episodic memory works). The information that is stored in semantic memory is independent of contextual elements. Although the retrieval in this memory is also guided by cues, these are not contextual in nature and their function is to instigate and unpack information in a fast and automatic way (Tulving, 1983).

To make the point of context as a defining feature between episodic and semantic memory more clearly, we try to illustrate it by an example. For instance, imagine a subject who is participating in a paired-associate task, and is instructed to learn a list with word pairs for later recall or recognition. The paired-associate task is a typical example of an episodic memory test (see above). We assume that during learning each word pair is encoded in an episode and is associated with contextual information (Raaijmakers & Shiffrin, 1981b; van Winsum-Westra, 1990). This contextual information is considered to exist at several levels (Glenberg, 1979). At a global level contextual information refers for instance to the particular building or room where the experiment takes place. It also includes the time of the day during which the experiment is performed. At a more specific level the particular list with words and the particular mode or format in which the words are presented, i.e. uppercase versus lowercase, on paper or on a computer screen, color of the letters etc., constitute the contextual information. Also, the emotional and physiological condition of the subject, whether being nervous, relaxed, hungry or having a cold, form a part of the context at this level. At test one word of a studied paired-associate pair is given as cue, and the subject is required to recall the other word or to recognize a complete word pair as 'old'. It is assumed that the cued recall of a paired-associate or the recognition of a word pair as old is also guided by the contextual elements (Mensink & Raaijmakers, 1988, 1989; van Winsum-Westra, 1990). Further, if the interval between the study and the test of learned word pairs increases, then the recall or recognition performance decreases. The reason is that with a longer interval there is less contextual overlap between study and test, and therefore there are less contextual elements available that can guide the retrieval process.

As was already noted, the information or knowledge units in semantic memory are assumed to be context-independent. Information is added to semantic memory by presenting it in several, different contexts, where it is then represented with some average of these contexts (Humphreys, Bain & Pike, 1989; Dosher & Rosedale, 1991). The important point is that semantic memory is a kind of generic memory without any reference to specific episodes. Evidence for the addition of newly learned information to a generic memory without any remembering of the specific context where the information was learned, was given by Watkins and Kerkar (1985). Subjects learned a list with single words for later free recall. Some words were presented twice, some words only once. To each presentation of a word a specific attribute was added, for instance the colour of the printed word, that formed the context of the word. Watkins and Kerkar showed that with the enhanced free recall of words presented twice in comparison to words only presented once, there was no concomitant enhancement of the free recall of the attributes, and thus no enhancement of the remembrance of the specific contexts in which a word was presented.

There are some investigators (Barsalou, 1982; Hintzman, 1986) who have suggested that part of the information in semantic memory is also context-dependent. For instance, Barsalou (Experiment 1, 1982) showed that the speed of verification of some properties of a concept was dependent on a relevant context. Barsalou argued that this finding constitutes a problem for the distinction between episodic and semantic memory. However, Barsalou demonstrated context-dependency in a semantic memory task and in that case context refers to the instigating function of a cue. A term can have several meanings (e.g., the term *bank*) and dependent on the meaning of the cue one part of the term is activated. Context-dependency in an episodic memory task refers only to the temporal and spatial aspects of information and a contextual cue is utilised to activate the information contained in episodes.

In summary then, on the basis of the considerations stated above, we define an association as episodic if its retrieval is dependent on the contextual cues that were present during study, and an association as semantic if there is no such dependency.

A second feature that defines the distinction between episodic and semantic memory is the speed of retrieval. Tulving (1983) stated that the cue-dependent retrieval of information from episodic memory is slow and deliberate, while the retrieval of information from semantic memory is fast and automatic. There is, however, evidence that the retrieval from episodic memory can also be fast and automatic. In experiments with the lexical decision task, reaction times to word targets preceded by episodically related primes were facilitated (McKoon & Ratcliff, 1986; Durgunoglu & Neely, 1987). This effect, referred to as episodic priming, was found under conditions that excluded the operation of strategic or anticipatory components by using a short Stimulus Onset Asynchrony between prime and target. Neely (1977) has shown that strategic components are operative when the SOA between a prime and target in lexical decision is equal to or larger than 400 ms. With a small SOA of 250 ms an automatic component is operative. Additional evidence against the idea that episodic and semantic information differ as to how fast they are retrieved was given by Dosher & Rosedale (1991). They showed that the retrieval processes of episodic and semantic associations have the same time course. Subjects had to recognize whether two words were studied together earlier during the experiment, which was a test for episodic associations, or to judge whether two words are related, which formed a test for semantic associations. It was found that the Speed Accuracy Tradeoff function, relating retrieval time to d', i.e. a measure for giving a correct response, was similar for the episodic and semantic associations. In conclusion then, it seems that under some conditions episodic associations can be retrieved as fast and automatically as semantic associations[1].

The characteristics of episodic and semantic associations with respect to context-dependency and speed of retrieval as stated in this section, provide useful guidelines in order to study the addition of newly learned associations to semantic memory.

1.4. Empirical evidence for the distinction between episodic and semantic memory.

Initially, Tulving's theory (1972) about the distinction between episodic and semantic memory attracted the attention of several investigators, with a concomitant discussion

---

[1] Everyone who has ever played trivial pursuit knows that the retrieval of semantic knowledge can sometimes be very slow and deliberate (Hirst, 1984).

between proponents of the distinction between both memory systems (e.g., Atkinson, Herrmann & Wescourt, 1974; Kinsbourne & Wood, 1975; Shoben, Wescourt & Smith, 1978; Herrmann & Harwood, 1980) and opponents (e.g., Anderson & Bower, 1973; McKoon & Ratcliff, 1979; Anderson & Ross, 1980). Later, as noted, Tulving (1983, 1984) has elaborated his theory by means of providing an account of 28 diagnostic features for the assumed distinction. Tulving reviewed the empirical evidence[1] in support of the distinction, that to his opinion had been provided by other investigators by means of the methods of transfer and experimental dissociation. The idea behind transfer is that if it is found that information stored in one memory system does not transfer to a memory task that is supposed to reflect the working of the other memory system, then that suggests that the memories are independent. Experimental dissociation means that if it is shown that the manipulation of an experimental variable has an effect in a memory task supposed to reflect the working of one memory system, but no effect or the opposite effect in a memory task supposed to reflect the working of the other memory system, then this result suggests the independence of both memory systems. With the method of experimental dissociation it had already been shown, quite reliably, that there is a distinction between short-term and long-term memory (for an overview see Raaijmakers, 1984 or Schwartz & Reisberg, 1991). However, the evidence put forward by Tulving in favour of the distinction between episodic and semantic memory is not convincing. For example, Tulving refers to a study by Shoben, Wescourt and Smith (1978) who demonstrated that manipulating semantic relatedness between the subject and predicate of a sentence has an effect on the time to verify whether a sentence (e.g., 'tigers have stripes') is true or false, but no effect on the time to recognize the sentence as being studied. This constitutes an experimental dissociation: An experimentally manipulated variable (semantic relatedness) has an effect in a semantic memory task (sentence verification), but no effect in an episodic memory task (sentence recognition). Shoben et al. demonstrated further that fanning, that is the number of facts learned in association with a concept, had an effect on sentence recognition time, but not on sentence verification time. Thus Shoben et al. had

[1] Tulving has only done few investigations (e.g., Tulving, Hayman & McDonald, 1991) in order to put his theory to an experimental test. In a reply to criticism of his theory (Mckoon, Ratcliff & Dell, 1986) he noted that because his theory is in fact an attempt at classification of phenomena and processes in semantic and episodic memory, the hypothetico-deductive method is not an appropriate procedure for evaluating the validity of such a classification (Tulving, 1986).

also found a second (episodic) variable that had an effect in the episodic memory task, but not in the semantic memory task. The double experimental dissociation led Shoben et al. to the conclusion that episodic and semantic information are represented in independent memory systems.

If it is assumed that two memory systems are independent, then it is still not clear whether they are structurally or functionally independent (Anderson & Ross, 1980). The information in both systems can have different representations although they both obey the same functional laws, and vice versa, both systems obey different functional laws but they have the same representational format. And if both memory systems are strictly independent, then of course this means that they are structurally and functionally independent, thus each system having its own representations and obeying its own functional laws. Just on these considerations McCloskey and Santee (1981) have criticized Shoben et al.'s conclusion that the double experimental dissociation they had found, implied that the information in episodic and semantic memory is differently represented. They argued that without assuming any differences in how the information is represented, the results of Shoben et al. can still be explained by assuming that there are differences in how information is retrieved from episodic and semantic memory. This example demonstrates that, if the theory does not clearly state the assumptions about the structure and processes of episodic and semantic memory in terms of a model, then an experimental dissociation is open to several interpretations.

Tulving has taken the experimental results reported by Jacoby and Dallas (1981) as further evidence for the distinction between episodic and semantic memory[1]. Jacoby and Dallas found that manipulating the levels of processing of information during a study phase had an effect on the recognition of that information during a later test phase, but no effect on the perceptual identification of the same information. As recognition reflects the working of episodic memory, and perceptual identification that of semantic memory, the Jacoby and Dallas results constitute an experimental dissociation. Tulving assumed that in

[1] Others (e.g., Schacter, 1987; Richardson-Klavhen & Bjork, 1988) have taken Jacoby and Dallas' results as evidence for the distinction between explicit and implicit memory. It is assumed that explicit memory reflects the conscious recollection of recently presented information, as expressed in memory tasks like free recall, cued recall and recognition. Implicit memory is revealed by a facilitation or change in task performance that is attributable to information acquired during a previous study episode, *without* conscious recollection, and is expressed in memory tasks like word completion, lexical decision and perceptual identification.

recognition an individually learned episode has to be retrieved and in perceptual identification contact with some abstract representation in semantic memory is needed in order to identify the information. But as has been shown by Jacoby & Witherspoon (1982), the recognition of a word in a perceptual identification task is specific, i.e. sensitive to the context of an earlier presentation of the word. This suggests that perceptual identification can also be mediated by episodes, because by definition these are context-dependent. Further, Feustel, Shiffrin and Salasoo (1983) have shown that pseudowords (nonwords that are orthographically similar to words) that have been presented only once during a study trial, are identified better in perceptual identification than pseudowords that were not studied. If perceptual identification is solely dependent on abstract representations in semantic memory, then this would mean that pseudowords are added to semantic memory after only one study trial. This is very unlikely.

We have reviewed some of the problems in relation to the results put forward as experimental evidence for the distinction between episodic and semantic memory. The reader is referred to McKoon, Ratcliff and Dell (1986) for additional problems.

There has also been criticism to the use of experimental dissociations as a valid method for deciding whether episodic and semantic memory are distinctive systems. For instance Dunn and Kirsner (1988) showed that it cannot be logically inferred that an experimental dissociation implies the involvement of two distinctive processes. Only if a nonmonotonic relationship between the performance on two tasks is demonstrated, by Dunn and Kirsner referred to as a reversed association, then can it be concluded that more than one process is involved in the two tasks. Their argument is as follows. If a single-process model is true then the performance between two tasks, both dependent on this process, will be functionally related. Further, if the performance in a task is at least monotonically related to process efficiency, then the relationship between the performance on the two tasks will also be monotonic. Consequently, any violation of a monotonic relationship between the two tasks is sufficient to reject a single-process model[1]. Neely (1989) also criticized the use of experimental dissociations. He argued that two tasks must have equal task parameters, such as prior study of stimulus material, stimulus presentation, response

---

[1] For instance, manipulating the factor word frequency, has an effect in recognition, with low frequent words being recognized better than high frequent words, and the opposite effect in recall. This constitutes an experimental dissociation, but it is nevertheless assumed that both recognition and recall reflect the retrieval of the same information in episodic memory (see Gillund & Shiffrin, 1984 and Roediger, 1984).

modality, etc., and only differ as to the instruction that taps the assumed memory processes, before any firm conclusions about a distinction can be made. In most studies this has not been the case.

In conclusion then, the evidence for the functional and/or structural distinction between episodic and semantic memory is weak, and by now it is assumed that the two memories are closely interrelated components residing in one larger memory system (Tulving, 1985; Tulving & Schacter, 1990).

1.5. Definition of the research problem

Most research on episodic and semantic memory has investigated whether it can be shown empirically that the two memory systems are distinctive. An issue that has received less attention is under what conditions information is added to semantic memory (Dagenbach, Horst & Carr, 1990). In order to investigate this issue, there are some aspects that need to be considered (Wolters, 1984; Carr, Dagenbach, VanWieren, Radvansky, Alejano & Brown, in press). First, the addition of information to semantic memory must be based on learning experiences and the relevant question is how many learning experiences are needed. Next, if information is added to semantic memory then it should be context-independent. Consequently it must be shown that the information can be retrieved in a context that is different from the context where it has been stored. Further, information in semantic memory should be stored permanently and be less vulnerable to forgetting than information in episodic memory. If information has been added to semantic memory, then after some time interval it must be shown that the information is still present. Lastly, if it can be shown that the newly learned information has the same functional characteristics as the information that is already assumed to be stored in semantic memory, then it is very likely that the newly learned information has also been added to semantic memory.

The problem that has our main interest is under what conditions newly learned information is stored in semantic memory. To investigate this problem the aspects just considered provides us with some guidelines. In the previous sections we have discussed some of the characteristics of episodic and semantic associations. If it is shown that newly learned associations have the same functional characteristics as the semantic or preexperimental associations, for instance exhibiting an automatic, semantic priming effect in lexical decision, then it can be concluded that the newly learned information has been stored in semantic memory. Data from free association tests (e.g., Kucera & Francis, 1967; De Groot, 1980) provide norms in order to decide whether an association is preexperimental or not. The free association test is a semantic production task and a subject has to respond with the first word that comes to mind after seeing or hearing a word provided by the experimenter.

Before proceeding with a description of the general method, we first discuss a study that investigated the forming of new word codes in semantic memory, and provided the framework for the investigation of the forming of new semantic associations.

1.5.1. The formation of new word codes

Salasoo, Shiffrin and Feustel (1985) applied a paradigm in which the addition of newly formed word codes to semantic memory was demonstrated. They found that repetition of information was a sufficient condition for the formation of new word codes. In one experiment they showed that two components, an episodic and a semantic one, were operative during the learning of the information. Further, in a follow-up experiment after one year, it was found that the information had been permanently stored in semantic memory. Salasoo et al. repeatedly presented words and pseudowords (nonwords that are orthographically similar to words) in two perceptual identification tasks[1].

What Salasoo et al. found was that in both perceptual identification tasks, at first words were identified better than pseudowords. The advantage of words was attributed to the existence of unitized codes in semantic memory that help in identifying fragments of features or letters. During a period of several days Salasoo et al. repeatedly presented the same words and pseudowords in both perceptual identification tasks with a total of 30 repetitions. The initial advantage of words over pseudowords gradually disappeared and after the sixth presentation the identification of pseudowords was as good as the identification of words. Then, after the sixth presentation the identification of both words and pseudowords increased equally until the last repetition. One year after the learning

[1] The two perceptual identification tasks that Salasoo et al. used, were the Discrete Threshold Identification and the Continuous Threshold Identification task. In DTI, a single brief exposure of a word or pseudoword at some predetermined time was presented, followed by a mask. In CTI, the exposures of the word or pseudoword were repeated in rapid succession, each followed by a mask. On each exposure the presentation of the word or pseudoword was slightly longer relative to the mask. At some predetermined point the sequence was stopped.

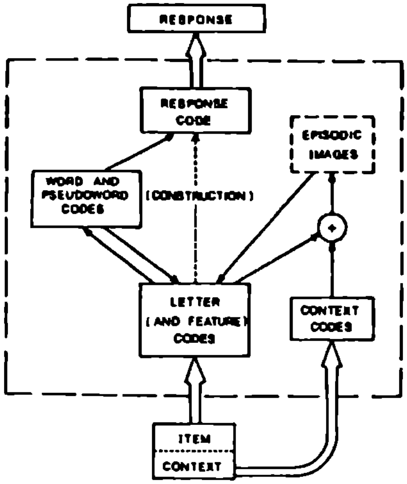

Figure 1.1. A proposed model for identification responses to words and pseudowords in a perceptual identification task. Adapted from Salasoo, Shiffrin and Feustel (1985).

phase, a follow-up experiment was conducted with the same words and pseudowords, and with new words and pseudowords presented in both perceptual identification tasks. Salasoo et al. found that the identification of the earlier studied words dropped to the level of the new words. They interpreted this as evidence for the assumption that during the learning phase the identification of words had been supported by episodes. Most interestingly however, was the fact that the identification of the studied pseudowords did not drop to the level of new pseudowords, but to the level of new words, i.e. to the same level to which the studied words dropped. This provided evidence for a semantic component. During the learning phase a unitized code in semantic memory had apparently been formed for the pseudowords, which explained the enhanced identification of the studied pseudowords in comparison to the new pseudowords. If this enhanced identification of pseudowords during the learning phase had been supported by episodes only, then after a year their identification should have decreased to the level of new pseudowords.

Salasoo et al. thus assumed that there are two components, an episodic and a semantic one, that play an interactive role in the identification of words and pseudowords. How this works is shown in Figure 1.1. In perceptual identification the detection of features and letters is supported by a word code in semantic memory. This explains the initial advantage of words over pseudowords. If words and pseudowords are repeated then the identification is also supported by episodes. But this only happens if the relevant contextual cues are present in order to retrieve the episodes. This explains the positive relationship between identification and number of repetitions. Gradually, during the learning phase a semantic code is formed for the pseudowords, which is context-independent. This then explains why after a year, when the relevant contextual cues are not available, the studied pseudowords are identified as well as the studied words. Note, that in Figure 1.1 it is assumed that episodic and semantic memory are interactive systems, one that is context-independent and the other that is context-dependent.

1.5.2 Learning new semantic associations

In this thesis not the formation of new word codes itself will be the main issue, but instead the formation of a new code that represents the relationship between two words in semantic memory, i.e. a new semantic association. To investigate this issue we use the learning paradigm of Salasoo et al., and make the same assumptions as outlined in Figure 1.1. Word pairs are repeatedly presented as prime-target pairs in two tasks: Lexical decision and perceptual identification. These tasks were described in section 1.2.2. To study the formation of new semantic associations, at least three categories of prime-target pairs are needed. First, semantically or preexperimentally related prime-target pairs are needed, and the magnitude of semantic priming observed with these pairs is used in order to establish a criterion or asymptote for semantic learning. In section 1.2.2 it was shown that the semantic priming effect refers to the processing of a target that is facilitated if preceded by a semantically related prime. Second, there must be a category with preexperimentally unrelated prime-target pairs, in order to demonstrate that associations that have been learned during the experiment, have been added to semantic memory. A final category of prime-target pairs must exist of neutral prime-target pairs, because there must be a baselevel condition in order to find out the magnitude of any learning effect. In this baselevel condition the forming of an association between the prime and target will be prevented. In the next section we will discuss how this can be done.

By presenting prime-target pairs repeatedly in a lexical decision or perceptual identification task, different types of learning effects are expected, that can all be detected with the three categories of prime-target pairs at hand. These learning effects are discussed in the next section. Our expectation is that in addition to any semantic learning effects, there will be also learning effects that are episodic in nature.

1.5.3. Expected priming effects

As an illustration, suppose that the three categories of prime-target pairs as described in the previous section, are repeatedly presented in a lexical decision task with short SOAs of 140 ms. We expect four types of learning effects that can be respectively referred to as the repetition priming effect, the semantic priming effect, the episodic priming effect and the priming effect that is the result of semantic learning. To what type of data pattern these four learning effects will lead, is shown in Figure 1.2. In this figure, the category with preexperimentally related prime-target pairs or semantic associations, which constitutes the criterion for semantic learning, is referred to as the SEM condition. The category with preexperimentally unrelated prime-target pairs or episodic associations, which form the associations that must be learned during the experiment, is referred to as the EPIS condition. Finally, the category with neutral prime-target pairs forms the NEU condition. Throughout this thesis the codes SEM, EPIS and NEU will be used to refer to the three conditions of prime-target pairs.

The first learning effect that is expected is that, regardless of the relationship between prime and target, reaction times will decrease as a result of repeating a target. This learning effect of repeated target presentation is generally known as the repetition priming effect (Forster & Davis, 1984; den Heyer, Goring & Dannenbring, 1985; Wilding, 1986). Second, as a result of the preexperimental relationship between prime and target, reaction times in the SEM condition are expected to be initially better than those in the other two prime-target conditions. This effect constitutes the semantic priming effect[1]. With a SOA of 140 ms we also expect that the semantic priming effect will be automatic (Neely, 1977). In addition, repeating the prime-target pairs of both the SEM and the EPIS condition leads to an episodic priming effect (McKoon & Ratcliff, 1979, 1986; Carroll & Kirsner, 1982; Neely & Durgunoglu, 1985; Durgunoglu & Neely, 1987). This means that word pairs, semantically related and unrelated, that are presented as to-be-learned-associations, show a priming effect that is based on episodes. Because in all our

[1] Of course, the semantic priming effect is not the result of any learning that took place during the experiment, but we can say that it is the result of learning that took place outside the laboratory.

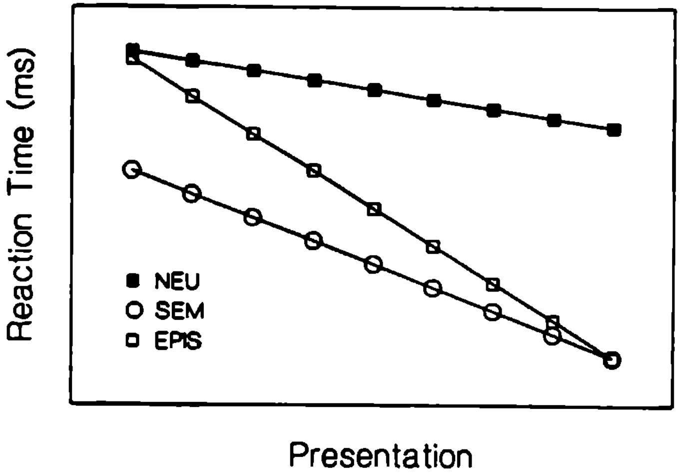

Figure 1.2. Expected pattern of reaction times (in milliseconds) as a function of category of prime-target pairing (SEM, EPIS and NEU) and number of presentations in a lexical decision task.

experiments the SEM condition consists of prime-target pairs that are semantically strongly related, according to word association norms, it is assumed that the links that represent these associations are not strengthened in semantic memory. Note that the episodic priming effect for the SEM condition is analogous to the contribution of episodes in the identification of words as depicted in Figure 1.1. The episodic priming effect for the SEM and EPIS conditions is shown in Figure 1.2 as a facilitation relative to the NEU condition. In the NEU condition it is always prevented that a predictive association is formed between the prime and the target. This can be done in two ways. First, each target in the NEU condition is preceded by the same prime, for instance by the word *blank*. Another way for creating a NEU condition is by using *changed pairs*. In that case, primes and targets are re-paired after each presentation of the NEU condition in lexical decision.

The last learning effect that is expected, is when a new semantic association has been learned between a prime and a target that are preexperimentally unrelated. In that case, as can be seen in Figure 1.2, there will be an interaction between the performance in the EPIS and the SEM condition, because the EPIS condition is facilitated more, due to semantic learning. This interaction is analogous to the interaction that Salasoo et al. found between the identification of words and pseudowords in their two perceptual identification tasks.

Note that the most important aspect of our paradigm is that we conclude that there is semantic learning if, and only if the performance of the EPIS condition approaches the performance of the SEM condition, other things being equal, like amount of repetition and episodic priming.

In summary then, by repeating prime-target pairs that are preexperimentally or semantically related (SEM condition), preexperimentally unrelated (EPIS condition) and neutral (NEU condition), we expect four different effects on lexical decision times (or proportion correctly identified targets in the perceptual identification task), resulting in a data pattern as is shown in Figure 1.2. Repetition priming is expected in all conditions, because it denotes a facilitation of target processing independent of prime-type. Semantic priming is only expected in the SEM condition, because it refers to facilitation of target processing by a prime that is preexperimentally related. Episodic priming is expected only in the SEM and EPIS conditions, because the effect refers to the facilitative processing by a prime that was repeatedly paired to the target during the experiment. Priming as a result of semantic learning is only expected in the EPIS condition, because the effect denotes the facilitation by a prime that was paired to and that became semantically related to the target during the experiment.

1.6. The experiments

To establish the sufficient conditions for learning new semantic associations, we carried out 10 experiments. These experiments will be described in detail in the Chapters 2, 3 and 4.

In Chapter 2, three experiments are reported in which prime-target pairs were repeatedly presented in the lexical decision task. In Experiments 1 and 2 evidence was found for episodic priming effects, but no evidence for semantic learning. It was concluded that merely presenting prime-target pairs (Experiment 1) and adding a paired-associate task (Experiment 2) are not sufficient for semantic learning. In Experiment 3 it was investigated whether semantic processing, more specifically sentence generation, might be sufficient for semantic learning. Also, in this experiment new vocabulary words were used as primes in order to prevent interference from competing associations in semantic memory. However, no indication of learning, episodic nor semantic, was found.

In Chapter 3, four experiments are described in which prime-target pairs were repeatedly presented in a perceptual identification task. The designs of Experiments 4 and 5 were similar to those of Experiments 1 and 2 respectively, but with fewer repetition trials. No evidence was found for episodic priming, nor any evidence for semantic learning. In Experiment 6, the design consisted of two phases in which prime-target pairs were presented for perceptual identification. After a learning phase of repeated prime-target presentations, without explicit instruction to study the word pairs, the performance of unchanged (semantically related and unrelated) prime-target pairs was compared to the performance of re-pairings of primes and targets (semantically related and unrelated) in a test phase. It was found that the unchanged pairs were facilitated relative to the re-pairings of primes and targets, and this was the case for both semantically related and unrelated pairs. This facilitation indicated an episodic priming effect for the prime-target pairs of the SEM and EPIS conditions. However, there was no indication that the newly learned associations of the EPIS condition were added to semantic memory. Experiment 7 was similar to Experiment 6, but to the learning phase a NEU condition with 'changed pairs' was added, and the subjects were instructed to explicitly study the prime-target pairs for later recall. No evidence was found for episodic priming, nor any evidence for semantic learning in the learning phase. However, the results of the test phase were a replication of the results in the test phase of Experiment 6: Episodic priming for both the EPIS and the SEM condition, but no indication of semantic learning.

In Chapter 4, in three experiments the role of context was investigated with respect to the learning effects. After repeating word pairs as prime-target pairs in a lexical decision task (Experiment 8) or as paired-associates in an explicit memory task (Experiment 9) during a learning phase, it was found that in a consecutive test phase there were only episodic priming effects for the SEM and EPIS conditions if the test context was similar to the study context. In Experiment 10 for the first time evidence was found for semantic learning. During a learning phase, all the word pairs were alternately presented as prime-target pairs for lexical decision and as paired-associates for an explicit memory task. Further, all word pairs were tested three times in a cued recall test. The results of the learning phase showed that the lexical decision times of the EPIS condition were facilitated more than those of the SEM condition, and thus indicated a semantic learning effect. These results were confirmed by the results of the consecutive test phase. In the test phase it was found that the learning effect for the EPIS condition transferred to a context that varied with the context at study. This transfer was not found for the SEM condition, which indicated only an episodic learning effect for this last condition, as was the case in the previous Experiments 8 and 9.

CHAPTER 2

LEARNING NEW SEMANTIC ASSOCIATIONS I: REPETITION OF PRIME-TARGET PAIRS IN LEXICAL DECISION, PAIRED-ASSOCIATE LEARNING AND SEMANTIC PROCESSING

Abstract - Three experiments (no. 1, 2 and 3) were carried out in which prime-target pairs were repeatedly presented in a lexical decision task. In all experiments word targets were preceded by a) preexperimentally related primes (SEM), or b) preexperimentally unrelated primes (EPIS), or c) neutral primes (NEU), these all being the word *blank* (Experiments 1 and 2) or changed primes (Experiment 3). The aim of the experiments was to find sufficient learning conditions for the forming of a semantic association between a preexperimentally unrelated prime and target. The learning conditions that were investigated were a) repetition, b) paired-associate learning and c) semantic processing with pseudowords as primes, in Experiments 1, 2 and 3 respectively. Although none of the experiments revealed evidence for semantic learning, there were nonetheless effects of episodic learning. That is, preexperimentally unrelated prime-target pairs (EPIS) were facilitated relative to neutral pairs by mere repetition and by paired-associate learning. Preexperimentally related prime-target pairs (SEM) showed episodic priming only with paired-associate learning. Episodic priming was always found relative to a NEU condition with all primes being *blank*.

2.1. Experiment 1

We first investigated whether repetition of word pairs, without explicit instruction to learn, is a sufficient condition for episodic priming and for the addition of newly learned associations to semantic memory. For that purpose we designed an experiment in which prime-target pairs were repeatedly presented in a lexical decision task. Thus all prime-target pairs were kept intact during the experiment, and there were no re-pairings. There were three word target conditions. One word target condition constituted the criterion for semantic learning and consisted of word targets that were all preceded by semantically related primes (SEM condition). The second word target condition was the condition with the newly learned associations and consisted of word targets that were all preceded by semantically unrelated primes (EPIS condition). The third word target condition was the baselevel condition and all word targets in this condition were preceded by the neutral prime *blank*.

The first experiment is partly a replication of Den Heyer's (1986) Experiment 2. In that experiment all word target categories were presented five times. The SOA for all prime-target pairs was equal to 150 ms. Den Heyer found no evidence for episodic priming, i.e. there was no interaction between the SEM and the NEU condition, and no interaction between the EPIS and the NEU condition. Since den Heyer might have used too few presentations to find an episodic priming effect for the SEM and EPIS conditions, we increased the total number of presentations to 16. The first 12 presentations were completed in three consecutive days. Approximately two weeks later, the last four presentations were given. This was done for the following reason. If we should find an indication for semantic learning then this effect should be still present after two weeks, because it is then assumed that the newly learned associations are permanently stored in semantic memory.

2.1.1. Method

2.1.1.1. Subjects

In Experiment 1 there were 17 subjects (10 female and 7 male) from the towns of Nijmegen and Maastricht. They had a mean age of 24.9 (SD = 8.9) years. All subjects had normal or corrected to normal vision and were native speakers of Dutch. They were all paid or received course credit for their participation.

2.1.1.2. Stimuli and apparatus

The stimulus material consisted of 72 prime-target pairs divided over three word target conditions, SEM, EPIS and NEU, and two nonword target conditions. All word targets were selected from lists provided by De Groot (1980). Of all prime-target pairs, 18 word-word pairs were semantically strongly related according to the word association norms of De Groot. These pairs formed the SEM condition. Mean association frequency in this condition was 58.4%. This association frequency is the percentage of subjects that gave the target as response to the presentation of the prime in a free association task. Next, 18 word-word pairs were selected that were not semantically related according to the same word association norms. According to these norms the target was never given as a response to the prime in a free association task. This implies that the mean association frequency in this condition is 0%. The condition with semantically unrelated prime-target pairs is the EPIS condition. Lastly, in the NEU condition all 12 word targets were paired to the Dutch equivalent of the word *blank* (*blanco*). This neutral prime was chosen, not because it has no semantic relation to the word target (De Groot, Thomassen & Hudson, 1982), but because this prime is paired with 12 different word targets so that it is prevented that a predictive association is formed between the prime and target during repetition (see also Den Heyer, 1986).

All word targets were matched with respect to word length and language frequency. The mean word lengths in the SEM, EPIS and NEU conditions were (standard deviations between parentheses) 4.8 (1.2), 4.8 (1.1) and 4.9 (1.4) letters respectively. Mean language frequencies were 74.3 (73.0), 74.6 (68.1) and 74.3 (58.8) occurrences per 600,000 words (Uit den Boogaart, 1975) respectively. All the prime-target pairs of the SEM, EPIS and NEU conditions can be found in Appendix B (page 136).

For nonword targets we used Finnish words. These were selected from a Finnish-Dutch dictionary ('t Hooft, 1987). Most of the Finnish words resembled Dutch words orthographically. In one condition there were 18 nonword targets with each nonword target paired to a Dutch word prime. In the other nonword target condition each of the six nonword targets was paired to the neutral prime *blank*. This condition was added because it prevents that a subject always has to respond with 'word' after seeing the neutral prime *blank*. A perfect correlation between the neutral prime status and a word response is undesirable, because it can lead to a decrease in reaction times in the NEU condition, and consequently to an underestimation of the episodic priming effect in the SEM and EPIS conditions. All the nonword targets and their primes can be found in Appendix B (page 138).

For the purpose of stimulus display, we used personal computers of the IBM microcomputer family. Measurement of reaction times was controlled by a Turbo Pascal (version 4.0) software timer written by Brysbaert, Bovens, d'Ydewalle and Van Calster (1989).

2.1.1.3. Procedure

The experiment consisted of four sessions distributed over four days. The first three sessions were on three consecutive days, the last session was appproximately two weeks after the third session, with a range of 13 to 21 days. Every session started with 42 practice trials, for the purpose of familiarizing the subject with the lexical decision task at the beginning of the first session, and for the purpose of warming-up during later sessions. Each session included four presentation blocks. In every presentation block all prime-target pairs of the three word target and the two nonword target conditions were presented once in semi-random order. A presentation block included six trial blocks. Each trial block consisted of the presentation of eight word targets and four nonword targets. Of all word targets, three word targets were paired to semantically related primes (SEM condition), three word targets were paired to semantically unrelated primes (EPIS condition) and two word targets to the neutral prime *blank* (NEU condition). Of all nonword targets, three nonword targets were paired to word primes, and one nonword target was paired to the neutral prime *blank*. Presentation order of prime-target pairs within trial blocks was fixed. Presentation order of trial blocks was randomised for every new presentation block. At the beginning of each trial block, two dummy prime-target pairs were inserted. Consequently, each presentation block also started with two dummy prime-target pairs. Dummy prime-target pairs were inserted in order to avoid slow reaction times as a result of missing the beginning of a presentation block.

An asterisk signalled the beginning of a new trial. Next, somewhat below and to the right of the position of the warning signal, the prime was shown for 100 ms. After a blank screen of 40 ms, below and to the right of where the prime was displayed, the target was shown. Consequently the SOA was equal to 140 ms. The target was shown on the computer screen until the subject responded with word ('?/'-key) or nonword ('Z'-key). After the subject's response always feedback was given. If the response was correct and faster than 900 ms, then 'GOED' (correct) was shown. If the response was correct but slow, between 900 and 2400 ms, then the word 'LANGZAAM' (slow) was shown to the subject. The words 'TE LAAT' (too late) were displayed, whenever the subject's response was slower than 2400 ms. An incorrect response was always followed by 'FOUT' (incorrect), independent of reaction time.

2.1.2. Results

2.1.2.1. Reaction time data

All reaction times shorter than 150 ms and longer than 900 ms were excluded from further analysis. All analyses were restricted to word targets. For each subject mean reaction times in each word target condition were calculated, and these means were submitted to statistical analysis. For the purpose of statistical analysis we followed the recommendations of Wickens and Keppel (1983) and treated our stimulus material as a fixed effect, and consequently carried out only a subject-analysis[1].

In Figure 2.1 the lexical decision times for the SEM, EPIS and NEU conditions as a function of presentation number are depicted. As can be seen, on Presentation 1 there is a large difference between SEM and NEU, which indicates a semantic priming effect. Further, lexical decision times in all three word target conditions decrease as a function of presentation number during the first three sessions. Faster reaction times in the NEU condition are the result of repetition priming. In addition, the data suggest that with more presentations the reaction times of the SEM and EPIS conditions are becoming relatively faster than the NEU condition. This is an indication for episodic priming. However, reaction times in the EPIS condition do not interact with those in the SEM condition. Thus there is no indication of semantic learning. On Presentation 13 on Day 4 the absolute level of lexical decision times in all three word target conditions has increased again and then decreases until Presentation 16.

We first performed an overall, three-way ANOVA on the reaction times of the first three days, with the within-subjects factors of prime type (SEM, EPIS and NEU), session (three days) and presentation (four presentations during each day). Main effects of prime type, session and presentation were all statistically significant with respectively $F(2,32) = 77.25$, $p < .001$; $F(2,32) = 24.35$, $p < .001$ and $F(3,48) = 12.67$, $p < .001$. The interaction between prime type and session was marginally significant ($F(4,64) = 2.43$, $.05 < p < .10$). All other interactions were not significant. The significant main effect of prime type, and the marginally significant effect of the interaction between prime type and

---

[1] There has been a long debate, starting with Coleman (1964) and Clark (1973), about the use of the correct statistics in research in which language materials are applied (see for instance Clark, 1976; Cohen, 1976; Forster & Dickinson, 1976; Keppel, 1976; Smith, 1976; Wike & Church, 1976; Coleman, 1979; Santa, Miller & Shaw, 1979; Wickens & Keppel, 1983). The point has been that if items are considered a random effect, then the performance of a subject-analysis, also referred to as a F_1 test, is not appropriate, because it can lead to serious bias. Therefore Clark recommended the use of quasi F or its lower bound *min* F'. Wickens and Keppel (1983) have shown by means of Monte Carlo simulations, that the matching of stimulus material on characteristics that correlate high with the response measure, such as word length and word frequency in the case of lexical decisions (Scarborough, Cortese & Scarborough, 1977; Becker, 1979; Norris, 1984), reduces the bias that accompanies a subject-analysis. In contrast, matching stimulus material leads to serious bias when *min* F' is used. In Appendix A (page 126) we discuss the relevant issues in more detail.

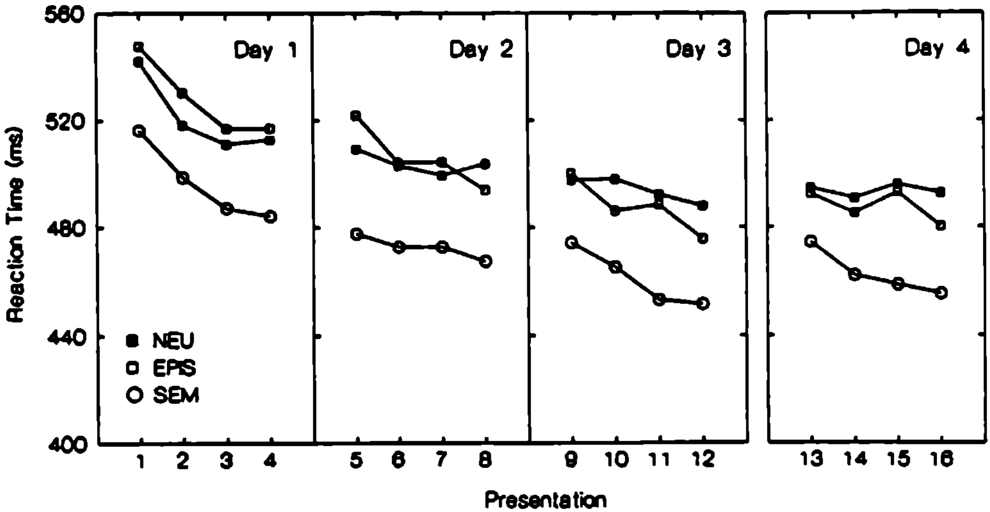

Figure 2.1. Reaction times (in milliseconds) in the lexical decision task of Experiment 1 as a function of prime-type (SEM, EPIS and NEU) and presentation number.

session was further analysed by comparing combinations of prime-types. Restricting the ANOVA to the SEM and NEU conditions resulted in significant main effects of prime type, session and presentation with respectively $F(1,16) = 114.19$, $p < .001$; $F(2,32) = 21.66$, $p < .001$ and $F(3,48) = 8.98$, $p < .001$. None of the interactions were significant. Next we restricted the ANOVA to the EPIS and the NEU condition. The main effects of session ($F(2,32) = 24.18$, $p < .001$) and presentation ($F(3,48) = 12.18$, $p < .001$) were highly significant, but the main effect of prime type was not ($F < 1$). The two-way interactions between prime type and session and between prime type and presentation were significant, with respectively $F(2,32) = 3.80$, $p < .034$ and $F(3,48) = 3.13$, $p < .035$. The three-way interaction was not significant. Lastly an ANOVA was performed with prime type restricted to the SEM and EPIS conditions. The three main effects of prime type ($F(1,16) = 176.38$, $p < .001$), session ($F(2,32) = 22.77$, $p < .001$) and presentation ($F(3,48) = 13.59$, $p < .001$) were all significant. If the newly learned associations had been added to semantic memory then at least one of the following interactions should be statistically significant: Prime type x Session, Prime type x

Table 2.1.
Error Percentages in the Lexical Decision Task of Experiment 1 as a Function of Prime Type (SEM, EPIS and NEU) and Presentation Number.

	Prime type				Prime type		
PN	SEM	EPIS	NEU	PN	SEM	EPIS	NEU
1	0.7	0.6	2.0	9	0.0	2.3	1.5
2	0.7	0.3	0.0	10	0.0	0.3	0.5
3	0.0	1.3	0.5	11	0.0	0.3	1.5
4	0.3	1.3	0.5	12	0.3	1.0	0.0
5	0.3	0.3	0.0	13	0.3	2.0	1.0
6	0.3	0.7	0.0	14	0.0	1.0	0.0
7	0.3	0.7	2.0	15	0.0	0.3	1.5
8	0.0	0.7	1.0	16	0.3	0.3	0.5

Note. PN = Presentation.

Presentation and Prime type x Session x Presentation. However, none of these interactions reached significance ($Fs < 1$). The analyses thus confirm that there is an episodic priming effect for the EPIS condition. But there is no evidence for semantic learning in the EPIS condition. In the SEM condition no effect of episodic priming is observed.

2.1.2.2. Error data

An error was scored whenever a subject responded with 'nonword' when a 'word' response was required[1]. In Table 2.1 the error percentages for the SEM, EPIS and NEU conditions are shown as a function of presentation number. It can be seen that, overall, the

[1] Of course, an error was also made whenever a subject responded with 'word' when a 'nonword' response was required. However, these errors were not analyzed further, not in Experiment 1, nor in any other experiment.

error percentages for the SEM condition are lower than those for the EPIS and NEU conditions. The results for the error data as shown in Table 2.1 indicate that the semantic priming effect cannot be simply explained by a Speed Accuracy Trade-off function.

2.1.3. Discussion

In the present experiment a reliable semantic priming effect of 40 ms was found. Further, the data showed that there was an additive relationship between semantic and repetition priming. Our results form a replication of the results of Den Heyer's (1986) Experiment 2. They are an extension of Den Heyer's results in the sense that he used only five presentations, while in this experiment there were a total of 16 presentations distributed over four sessions. The additive relationship between semantic and repetition priming indicates that there was no episodic priming for the associations in the SEM condition. However, a significant interaction was found between the EPIS and the NEU condition, which means that there was episodic priming for the newly learned associations. This result is in contrast with the data of Den Heyer's Experiment 2, which did not show an interaction between newly learned associations and neutral prime-target pairs. The next question is whether there was also evidence of semantic learning for the newly learned associations. No interaction was found between the SEM and the EPIS condition. Although repetition of semantically unrelated prime-target pairs in the lexical decision task is sufficient for an episodic priming effect, explicitly instructing subjects to learn these prime-target pairs by means of a paired-associate task might be necessary for semantic learning. Also, paired-associate learning might be necessary for the episodic priming effect in the SEM conditon.

2.2. Experiment 2

The purpose of the second experiment was to investigate whether explicitly learning the association between prime and target by means of a paired-associate task is a sufficient condition for the formation of a semantic association between the prime and target. The design was identical to that of Experiment 1, except that after each presentation block of lexical decision trials a paired-associate task was administered for the SEM and the EPIS conditions.

2.2.1. Method

2.2.1.1. Subjects

In the present experiment there were 19 subjects from the towns of Nijmegen and Maastricht. Of these 8 were male and 11 were female. Mean age was 23.2 years (*SD* = 7.0). All subjects had normal or corrected to normal vision and were native speakers of Dutch. They were paid or received course credit for their participation.

2.2.1.2. Stimuli and apparatus

The same stimuli and apparatus as in the previous experiment were used.

2.2.1.3. Procedure

As in Experiment 1, each prime-target pair was presented a total number of 16 times, with the first 12 presentations on three consecutive days, and the last four presentations approximately two weeks after the third day. The procedure for presentation of prime-target pairs in the lexical decision task was identical to the procedure of the previous experiment. After each presentation block of 84 lexical decision trials a cued recall task was administered. This was done as follows. The stimulus term of a prime-target pair was shown on the screen and the subjects were instructed to write down the response term on basis of what they could recall from earlier presentations during the lexical decision trials. Subjects were given seven seconds for recall after stimulus presentation, then the response term was shown on the screen. Only the 18 prime-target pairs of the SEM condition, and the 18 prime-target pairs of the EPIS condition were presented in this task. Administration of the cued recall task after a presentation block of lexical decisions was continued until the fifteenth presentation during Day 4.

2.2.2. Results

2.2.2.1. Reaction time data

Again, only the reaction times shorter than 900 and longer than 150 ms were submitted

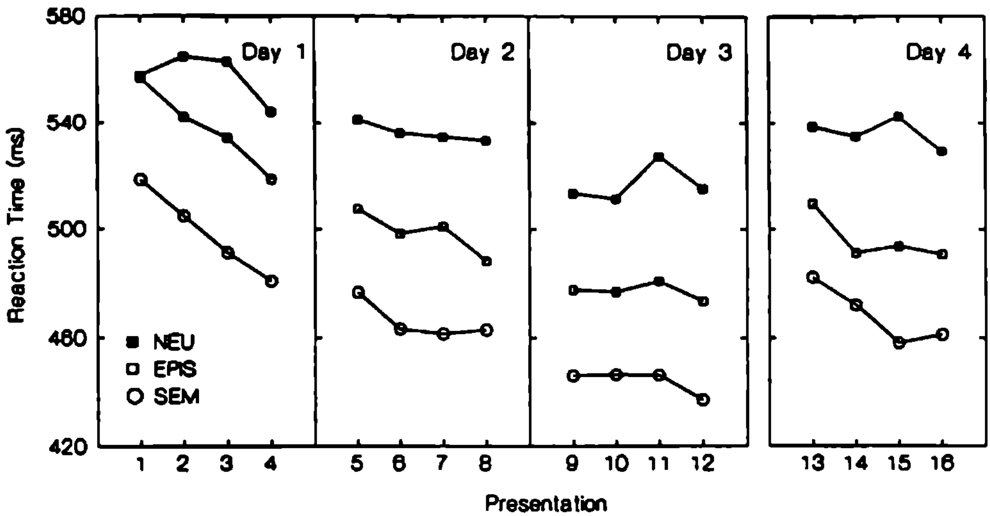

Figure 2.2. Reaction times (in milliseconds) in the lexical decision task of Experiment 2 as a function of prime-type (SEM, EPIS and NEU) and presentation number.

for statistical analysis. Only the results of the subject-analysis are reported, for the same reasons as in Experiment 1 (but see also Appendix A, page 126). Mean reaction times in the SEM, EPIS and NEU conditions were computed for each subject and these means were used for statistical analysis. The lexical decision times for the three word target conditions as a function of presentation number are displayed in Figure 2.2. Again, on the first three days lexical decision times became faster in all the three word target conditions. Because in the NEU condition no association can be formed between the prime and the target, faster reaction times in this condition are the result of repetition priming. In comparison to the NEU condition, the reaction times in the SEM and in the EPIS condition become relatively faster, and thus indicate an episodic priming effect. But the difference of approximately 38 ms between the SEM and the EPIS condition on Presentation 1 remains constant until Presentation 12 on Day 3. This means that there is no effect of semantic learning. After the time interval between Day 3 and Day 4 the absolute level of the reaction times of all word target conditions has increased, but decreases again until Presentation 16 on Day 4.

We performed an overall, three-way ANOVA with prime type (SEM, EPIS and NEU), session (three days) and presentation (four presentations within each session) as within-subjects factors on the lexical decision times of the first three days. This resulted in significant main effects of prime type ($F(2,36) = 154.99$, $p < .001$), session ($F(2,36) = 30.25$, $p < .001$) and presentation ($F(3,54) = 6.65$, $p < .002$). Further, of all the interactions tested, only the Prime type x Session and Session x Presentation were significant with respectively $F(4,72) = 5.21$, $p < .002$ and $F(6,108) = 2.76$, $p < 0.02$. In order to analyze the significant main effect of prime type and the significant interaction between prime type and session in more detail, we next restricted the ANOVA to combinations of prime-types. Restricting statistical analysis first to the SEM and NEU conditions, this resulted in significant main effects of prime type ($F(1,18) = 274.33$, $p < .001$), session ($F(2,36) = 23.27$, $p < .001$ and presentation ($F(3,54) = 4.57$, $p < .007$). The interactions between prime type and session and between prime type and presentation were statistically significant with respectively $F(2,36) = 4.13$, $p < .025$ and $F(3,54) = 4.231$, $p < .01$. These results diverge from Experiment 1, as there is now a significant interaction between semantic and repetition priming. Next we analyzed the combination of the EPIS and the NEU condition. In this analysis the main effects of prime type, session and presentation were all significant with respectively $F(1,18) = 58.48$, $p < .001$; $F(2,36) = 25.58$, $p < .001$ and $F(3,54) = 4.29$, $p < .01$. Of the interaction effects only the one between prime type and session was statistically significant with $F(2,36) = 7.42$, $p < .003$. The interaction between prime type and presentation was marginally significant with $F(3,54) = 2.33$, $.05 < p < .10$. The interaction between repetition and episodic priming involving newly learned associations is a replication of the results of Experiment 1. Finally, comparing the SEM with the EPIS condition, only the main effects were significant with $F(1,18) = 132.99$, $p < .001$ for prime type, $F(2,36) = 39.76$, $p < .001$ for session and $F(3,54) = 9.42$, $p < .001$ for presentation.

2.2.2.2. Error data

In Table 2.2 the error percentages as a function of prime-type (SEM, EPIS and NEU) and presentation number are depicted. Overall, as the results in this table indicate, less errors were made in the SEM condition. This again demonstrates that the reaction time data cannot be simply explained by a Speed Accuracy Trade off function.

Table 2.2.
Error Percentages in the Lexical Decision Task of Experiment 2 as a Function of Prime Type (SEM, EPIS and NEU) and Presentation Number.

PN	Prime type SEM	Prime type EPIS	Prime type NEU	PN	Prime type SEM	Prime type EPIS	Prime type NEU
1	0.6	2.0	2.2	9	0.3	0.9	0.9
2	0.3	1.2	0.4	10	0.0	0.3	2.6
3	0.0	0.3	0.0	11	0.6	0.3	0.4
4	0.6	1.3	0.9	12	0.0	0.0	1.3
5	0.3	0.0	0.4	13	0.6	0.3	3.9
6	0.0	0.9	1.3	14	0.0	0.0	1.3
7	0.0	0.0	0.4	15	0.3	0.0	3.1
8	0.0	0.3	1.8	16	0.0	1.8	0.0

Note. PN = Presentation.

2.2.2.3. Cued recall data

After each presentation block of prime-target pairs in the lexical decision task, a cued recall test was administered with the primes as stimulus terms and the targets as response terms. Only word targets of the SEM and the EPIS conditions were required as responses in the cued recall test. In Table 2.3 the mean percentages correctly recalled response terms are shown as a function of word target condition and presentation number.

As can be seen in this table, cued recall for the SEM condition is better than for the EPIS condition. Also, with increasing presentations, cued recall becomes better in both conditions.

2.2.3. Discussion

As in Experiment 1, we again found evidence for episodic priming in the EPIS condition. Contrary to the results of the previous experiment, in Experiment 2 episodic

Table 2.3.
The Mean Percentages Correctly Recalled Response Terms in the Cued Recall Test of Experiment 2 as a Function of Prime Type (SEM and EPIS) and Presentation Number.

	Prime type			Prime type	
PN	SEM	EPIS	PN	SEM	EPIS
1	89.2	15.8	9	99.7	98.2
2	96.5	47.1	10	100.0	99.4
3	98.8	73.7	11	100.0	98.8
4	100.0	84.5	12	100.0	99.1
5	91.1	88.0	13	99.4	94.4
6	100.0	94.7	14	100.0	98.2
7	100.0	97.4	15	100.0	99.1
8	99.7	98.0			

Note. PN = Presentation.

priming was found for the SEM condition. The episodic priming with newly learned associations is a replication of findings in earlier studies that have shown episodic priming with short SOAs and paired-associate learning (McKoon & Ratcliff, 1986; Durgunoglu & Neely, 1987). Durgunoglu and Neely (1987) listed the conditions under which it is most likely to find episodic priming with short SOAs in the lexical decision task. It is obtained only if a) all word targets are studied and all nonword targets are not studied, and b) no SEM condition is tested. Having all word targets studied and all nonword targets nonstudied makes the information concerning the study status of the target, independent of its lexical status, useful in the decision process. Subjects are biased to respond 'word' when they recognize that the item has been studied earlier, otherwise they respond with 'nonword'. Durgunoglu and Neely argued that this response bias explains much of episodic priming in the lexical decision task. It is unlikely that response bias explains the episodic priming that we found in Experiment 1. All targets, words and nonwords, were repeated in an equal number of presentations. Thus given the fact that targets were matched with respect to the amount of learning, it is hard to conceive how target response bias could have explained episodic priming. In addition, the episodic priming in Experiment 1 was found in the presence of semantically related prime-target pairs.

In Experiment 2, prime-target pairs were presented under similar conditions as in Experiment 1. All targets were presented equally often for lexical decision, but in addition only the word targets of the SEM and EPIS conditions were tested during a cued recall test. This constitutes a complication, in so far that the episodic priming can be explained by a smaller repetition priming effect in the NEU condition as compared to the SEM and EPIS conditions. Note that we assume that there is repetition priming in all word target conditions as a result of repeating targets (see also Chapter 1).

Adding a cued recall test after each block of lexical decision trials did not lead to an interaction effect between the reaction times of the EPIS and the SEM condition. Therefore it seems justified to conclude that repetition of prime-target pairs and explicit learning in the form of a cued recall test are not sufficient factors for semantic learning.

Dagenbach, Horst and Carr (1990) also failed to find evidence for the formation of a new semantic association between words being preexperimentally unrelated. They suggested two reasons for this failure. The first reason is that the formation of a new semantic association might be hindered as a consequence of interference effects. It is assumed that semantic memory is an architecture in which each word has links with many other words (Collins & Loftus, 1975; Anderson, 1983). Creating a new semantic association between two words is difficult, because any attempt to form a new link has to compete with existing links. This problem might be overcome if a new word code is added to semantic memory. A new word, unfamiliar to the subject or a pseudoword, does not yet have any links with other words, so the problem of competitive links is avoided. The second problem with the creation of a new semantic link between words has to do with the nature of the learning task. A semantic association between words implies a meaningful relationship between them. Creating a new semantic link might require an elaborative learning task where the meaning of the words is used. Several authors have stressed that this elaborative processing is necessary in the formation of episodic associations (Graf & Schacter, 1985; Schacter & Graf, 1986; Smith, MacLeod, Bain & Hoppe, 1989; Howard, Fry & Brune, 1991). So, this kind of processing might be even more needed in case of learning new semantic associations, as was also suggested by Dagenbach et al.

To investigate these issues, we designed Experiment 3. The same paradigm as in the two previous experiments was used, but with the addition of two manipulations. First, instead of presenting word primes in the EPIS condition we presented pseudoword primes in this condition. Before these pseudoword primes were presented in the lexical decision task, there was an initial study phase where subjects had to learn a semantic definition to each of these pseudoword primes. This was done in order to increase the likelihood that a unitized code (Salasoo, Shiffrin & Feustel, 1985) for each pseudoword was added to semantic memory. Secondly, in order to enforce elaborative processing of newly learned associations, we applied a sentence generation task after each presentation block of lexical decision trials. In the sentence generation task subjects were required to generate sentences in which the meaning of both the prime and the target were used. With this task we also manipulated another factor. By instructing the subjects to create an original sentence for each prime-target pair at each presentation, we varied the learning context at each presentation, with the idea that this would also lead to semantic learning (Kintsch, 1974; Hintzman & Stern, 1978; Nitsch, in Bransford, 1979).

Experiment 3 is similar to the study by Dagenbach, Horst and Carr (1990). In their Experiment 3, the facilitation of lexical decision times in the condition with the new associations, all having newly learned vocabulary words as primes, was of the same magnitude as the semantic priming effect. They concluded that this result was evidence for the addition of the newly learned associations to semantic memory. But the targets in their SEM condition were not repeated as often as the targets in their EPIS condition during the learning phase of the experiment. Consequently, had the targets in both conditions been matched with respect to number of presentations, it is not unlikely that the facilitation in the SEM condition had been larger. In our view, what Dagenbach's et al. Experiment 3 has demonstrated is at most an episodic priming effect with the newly learned associations. Semantic learning is only demonstrated if the facilitation in the EPIS condition has the same magnitude as the facilitation in the SEM condition, *other things being equal*. In our Experiment 3, as was the case in the previous experiments, the targets in the SEM condition were presented as often as the targets in the EPIS condition during the learning phase.

2.3. Experiment 3

The purpose of the third experiment was to investigate further the sufficient conditions for the addition of newly learned associations to semantic memory. As was the case in Experiments 1 and 2, prime-target pairs were repeatedly presented in the lexical decision task. Again, the SEM condition constituted the criterion for semantic learning, and thus consisted of semantically related prime-target pairs.

In contrast to the previous experiments, the primes in the EPIS condition now consisted of newly learned vocabulary words. These new words were in fact pseudowords to which subjects were required to learn a semantic definition in an initial study phase. During the lexical decision trials the EPIS condition was split into two subconditions: EPIS-S^+ and EPIS-S^-. In the EPIS-S^+ condition the semantic definition of the pseudoword was closely related to the meaning of the target. In the EPIS-S^- there was no semantic relationship between a pseudoword and the target it was paired to. Varying semantic relatedness between the definition of a pseudoword and the meaning of the target was done in order to have some means of inspecting the integration of the pseudowords into the semantic network. If learning a semantic definition is sufficient for the integration of the pseudoword into the semantic network (or the forming of a unitized code), then it should be observed that there is a facilitative effect to the lexical decision time of a target that is preceded by a semantically related pseudoword, in contrast to a target that is preceded by a semantically unrelated pseudoword.

Also in contrast to the previous experiments, the NEU condition now contained 'changed pairs', i.e. targets were re-paired to primes during each presentation block in the lexical decision task.

2.3.1. Method

2.3.1.1. Subjects

The subjects were 30 students from the University of Nijmegen. All were paid or received course credit for their participation. There were 13 male and 17 female subjects with a mean age of 22.6 years (*SD* = 3.9). All subjects reported normal or corrected-to-normal vision and were native speakers of Dutch.

2.3.1.2. Stimuli and apparatus

There were 33 prime-target pairs distributed over five word target and two nonword target conditions. As in the previous experiments, all word targets were chosen from De Groot's (1980) stimulus lists and all nonword targets were Finnish words selected from 't Hooft's (1987) Dutch-Finnish dictionary. One word target condition, SEM, consisted of four semantically related prime-target pairs with a mean association frequency of 84.5% according to the word association norms of De Groot. Two other word target conditions had pseudowords as primes. These pseudowords were created with the restriction that they should be orthographicallly similar to Dutch words. In the initial study phase of the experiment subjects learned a semantic definition to each pseudoword (see also procedure, below). In one pseudoword condition, EPIS-S^+, the meaning of each word target was closely related to the semantic definition of the pseudoword it was paired to. In the other pseudoword condition, EPIS-S^-, there was no semantic relationship between the word targets and the definitions of the pseudowords they were paired to. Both pseudoword conditions contained four prime-target pairs.

The remaining two word target conditions were neutral prime conditions, both consisting of four prime-target pairs. In one condition, NEU-WP, word targets were paired to word primes, in the other condition, NEU-PP, they were paired to pseudoword primes. Subjects also learned a semantic definition for the pseudowords in this condition during the initial study phase of the experiment. At every new presentation during lexical decision the prime-target pairs of the neutral conditions were re-paired. As in Experiments 1 and 2 we prevented that in the neutral condition a prime and a target could become associated. The reason for choosing re-pairing of prime-target pairs instead of pairing each target to the neutral prime *blank* was that prime-target pairs of the neutral condition should also be applied in the sentence generation task. This is important because in that case the targets of all conditions are matched with respect to the magnitude of repetition priming. Remember that in Experiment 2 targets were not matched with respect to repetition priming and this constituted a possible confounding in the experiment.

All word target conditions had approximately equal word frequencies (Uit den Boogaard, 1975) with mean frequencies (standard deviations between parentheses) of 23.3 (20.1), 23.8 (21.9), 22.8 (21.9), 21.8 (8.0) and 21.5 (4.4) in the SEM, EPIS-S^+, EPIS-S^- NEU-WP and NEU-PP conditions respectively. The mean target lengths in these conditions were 4.8 (1.0), 4.5 (0.6), 5.0 (0.8), 4.8 (1.0) and 4.8 (1.0) respectively.

One nonword target condition contained five pairings of word primes and Finnish words, the other nonword target condition was a neutral condition in which the eight prime-target combinations were re-paired at every new presentation of these pairs in the lexical decision task.

Stimuli were displayed on the screen of a 2 MT Olivetti personal computer. Reaction time registration was controlled by the same software as in Experiments 1 and 2.

2.3.1.3. Procedure

There were two learning phases in Experiment 3. During the first phase, subjects learned the meaning of pseudowords by means of definitions provided by the experimenters (see Appendix B, page 139, for a list of the pseudowords and their definitions). In the second learning phase, after learning the definitions of the pseudowords, all prime-target pairs were repeatedly presented in the lexical decision task in combination with a sentence generation task. Prime-target presentation in the lexical decision task was as described in the procedure section of Experiment 1. In addition to feedback about response accuracy also feedback about speed was given, i.e. after each word/nonword decision the reaction time was shown to the subject. Before the two learning phases all prime-target pairs were presented once in the lexical decision task. This was done in order to obtain pretest reaction times of all prime-target pairs.

After the pretest lexical decision trials subjects received a list with 12 pseudowords and their definitions. They were instructed to study the pseudowords and their definitions in both ways: Naming the pseudoword in response to the definition provided by the experimenter and vice versa, reciting a definition in response to a pseudoword named by the experimenter. Literal recitation of a definition was not obligatory, it was sufficient to name all essential features of the pseudoword's meaning. The bi-directional learning was repeated until perfect learning was achieved, i.e. a subject could name all pseudowords in response to the definitions and could recite all definitions in response to the pseudowords without error. During the initial study phase subjects were also instructed to generate meaningful sentences with the newly learned pseudowords. The sentences were recorded on tape. Then, at the end of the initial study phase subjects were told that on the next session the newly learned words and their definitions would be tested again.

In the second learning phase of the experiment all prime-target pairs of the word and nonword target conditions were repeatedly presented in the lexical decision task. At the beginning of the second learning phase, knowledge of the pseudowords and their definitions was tested again and if the subjects made any errors, they were again required to study until they named all pseudowords in response to definitions and recited all definitions in response to pseudowords perfectly. Only then the second learning phase of the experiment was started.

During the second learning phase prime-target pairs in the lexical decision task were presented 12 times in two sessions of six presentations each. The two sessions were on two separate days with an average interval of 48 hours between the two days. Each session was preceded by 32 practice trials for the purpose of warm-up. In each presentation block prime-target pairs were presented in random order to each subject. Every presentation block, except for the last presentation block, was followed by a sentence generation task. A prime and its paired word target were displayed on the computer screen and the subjects were instructed to generate a meaningful sentence with both the prime and target. It was stressed that sentences should be original, and a subject should avoid the use of similar sentences. The sentences generated by the subjects were recorded on tape.

2.3.2. Results

2.3.2.1. Reaction time data

Reaction times shorter than 150 ms and longer than 900 ms were excluded from further analysis. For each subject mean reaction times were calculated in each word target condition and these were submitted to ANOVA. For the same reason as in the previous experiments only the results of the subject-analysis are reported (see Appendix A, page 126). In Figure 2.3 the lexical decision times of the five word target conditions are displayed as a function of presentation. As can be seen in this figure, word target conditions differed with respect to baselevel lexical decision times at the beginning of the first learning phase. These pretest differences remained at the beginning of the second learning phase. A two-way ANOVA with prime type (five word target conditions) and presentation (pretest = Presentation 1, posttest = Presentation 2) as within-subjects factors was performed. Only the main factor of prime type was significant ($F(4,116) = 15.68$, $p < .001$). The interaction between prime type and presentation was not significant ($F < 1$). In the following, only the results of the second learning phase (Day 1 and Day 2) are reported. Generally, lexical decision times in all the word target conditions decrease as a function of presentation number. The decrease in the NEU-WP and the NEU-PP conditions is the result of repetition priming. Contrasting the SEM condition with the NEU-WP condition, it can be seen that the reaction times in the former condition are not becoming relatively faster than the reaction times in the latter condition. Thus there is no episodic priming with preexperimental associations. Further, by contrasting the EPIS-S$^+$ and the EPIS-S$^-$ condition with the NEU-PP condition, the data in Figure 2.3 suggest that there is no episodic priming either with the newly learned associations containing

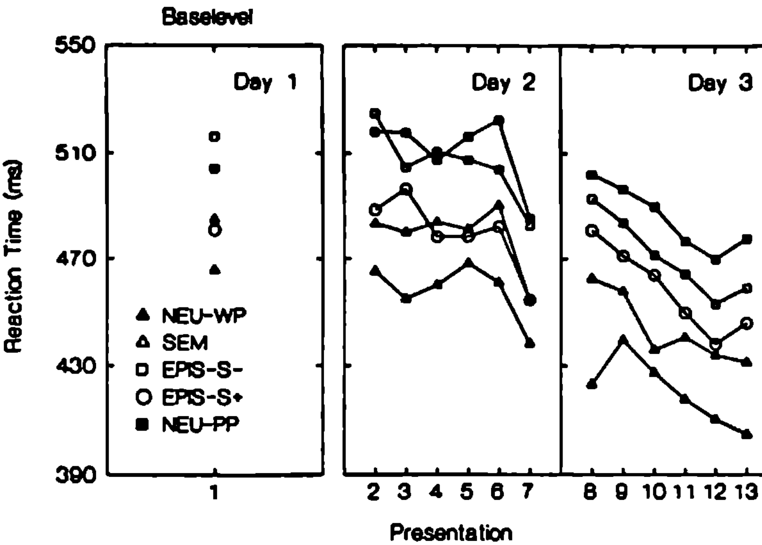

Figure 2.3. Reaction times (in milliseconds) in the lexical decision task of Experiment 3 as a function of prime-type (SEM, EPIS-S^+, EPIS-S^-, NEU-WP and NEU-PP) and presentation number.

pseudowords as primes. The data suggest however, that the difference between the EPIS-S^+ and the EPIS-S^- condition becomes smaller on Day 3 as compared to Day 2. Finally, it can also be seen that there is no indication of semantic learning. The differences in lexical decision times between the SEM condition on the one hand and the EPIS-S^- and the EPIS-S^+ condition on the other hand become larger on Day 3 as compared to Day 2. For statistical analysis we restricted the ANOVA to combinations of the levels of prime type. First we combined SEM and NEU-WP. This resulted in significant main effects of prime type ($F(1,29) = 45.55$, $p < .001$), session ($F(1,29) = 67.52$, $p < .001$) and presentation ($F(5,145) = 4.90$, $p < .001$). Only the interaction between session and presentation ($F(5,145) = 3.12$, $p < .012$) was significant. This interaction means that the reaction times on Day 3 decreased faster than on Day 2. Next we combined EPIS-S^+, EPIS-S^- and NEU-PP of the prime type factor for statistical analysis. There were again significant main effects of prime type ($F(2,58) = 40.57$, $p < .001$), session ($F(1,29) = 28.69$, $p < .001$) and presentation ($F(5,145) = 10.68$, $p < .001$). The interaction between session and presentation ($F(5,145) = 3.39$, $p < .006$) was also significant. All other interactions were not significant. The data in Figure 2.3 that suggest that the difference between the EPIS-S^+ and the EPIS-S^- condition becomes smaller on Day 3 as compared to Day 2 is not confirmed by the statistical analysis. Lastly, we performed an ANOVA with a combination of SEM, EPIS-S^+ and EPIS-S^- on the prime type factor. The main factors of prime type ($F(2,58) = 77.31$, $p < .001$), session ($F(1,29) = 39.34$, $p < .001$) and presentation ($F(5,145) = 9.18$, $p < .001$) were all significant. Of the interactions, only the one between prime type and session ($F(2,58) = 4.68$, $p < .015$) and the one between session and presentation ($F(5,145) = 2.61$, $p < .03$) were significant. As can be seen in Figure 2.3, the interaction between prime type and session means that the difference between the semantic associations and the newly learned associations became larger from Day 2 to Day 3.

2.3.2.2. Error data

In Table 2.4 the error percentages for the SEM, EPIS-S^+, EPIS-S^-, NEU-WP and NEU-PP conditions are shown as a function of presentation number. By comparing Table 2.4 with Figure 2.3, the error data are globally similar to the reaction time data, i.e. performance in the SEM, EPIS-S^+ and NEU-WP conditions is better than in the EPIS-S^- and NEU-PP conditions.

2.3.3. Discussion

In Experiment 3, in contrast to Experiments 1 and 2, no evidence was found for episodic priming, neither in the SEM condition, nor in the EPIS conditions. A fortiori, no new semantic learning was observed. It is therefore likely that the facilitation of lexical decision times was only due to repetition priming. The reason for the failure of finding facilitative priming effects in the EPIS conditions may be that, although subjects learned the semantic definitions of the pseudowords perfectly in the initial learning phase, this learning was not sufficient for the addition of a unitized code to the semantic network. As a consequence it was not possible to form new associative links between words (targets) and pseudowords (primes). In other words, it is very likely that the formation of a unitized word code is a necessary first step for the formation of a code that represents an episodic or semantic relationship in memory.

Dagenbach, Horst and Carr (1990, Experiment 3) did find episodic priming with targets

Table 2.4.
Error Percentages in the Lexical Decision Task of Experiment 3 as a Function of Prime Type (SEM, EPIS-S$^+$, EPIS-S$^-$, NEU-WP and NEU-PP) and Presentation Number.

	Prime type				
PN	SEM	EPIS-S$^+$	EPIS-S$^-$	NEU-WP	NEU-PP
1	2.5	0.8	8.3	4.2	6.7
2	1.7	2.5	5.8	3.3	3.3
3	0.8	0.8	4.2	2.5	3.3
4	0.8	1.7	3.3	1.7	2.5
5	0.8	0.0	2.5	0.0	1.7
6	0.8	0.8	0.0	0.0	0.8
7	0.8	0.0	2.5	0.0	1.7
8	0.0	2.5	4.2	1.7	1.7
9	0.8	0.8	1.7	0.8	1.7
10	0.0	0.0	3.3	3.3	0.0
11	0.8	0.8	3.3	0.8	1.7
12	0.0	1.7	2.5	0.0	0.8
13	0.0	1.7	2.5	0.0	0.8

Note. PN = Presentation.

preceded by newly learned vocabulary words. There are some factors that might explain the difference between their and our results. First, instead of pseudowords, Dagenbach et al. used words that were unfamiliar to the subjects, like *sopor*, *dictum* and *aubade*. These unfamiliar words formed the primes and were paired to targets that were their synonyms. Although the subjects indicated that they did not know the primes, it is not unlikely, that by providing their synonyms, the unitized codes of these apparently unfamiliar words became activated in the semantic network. Consequently, the unfamiliar primes paired to their synonyms became semantically related prime-target pairs, and therefore showed facilitation. A second factor that might explain the difference between our and Dagenbach's et al. Experiment 3, is that Dagenbach et al. also applied a paired-associate task. In our experiment, subjects were not explicitly instructed to study the prime-target pairs (as was done in Experiment 2).

In any event, the most important conclusion of Experiment 3 is that sentence generation and the use of newly learned vocabulary words as primes are not factors that played a role in the absence of a semantic learning effect in Experiments 1 and 2.

2.4. General discussion

In this chapter three experiments were reported in which the forming of new semantic associations was investigated by means of repeating prime-target pairs in a lexical decision task. In none of the experiments evidence was found for semantic learning. However, there was an effect of episodic learning in lexical decision, for newly learned associations in the EPIS condition (Experiments 1 and 2), as well as for preexperimental associations in the SEM condition (Experiment 2).

Summarizing the results of the three experiments with respect to episodic priming in lexical decision we can say that a) merely repeating prime-target pairs was sufficient for episodic priming with newly learned associations (EPIS) b) repeating prime-target pairs and paired-associate learning were sufficient for episodic priming with preexperimental associations (SEM) c) the episodic priming was always observed relative to a NEU condition with targets preceded by the neutral prime *blank*.

In Experiment 3 no evidence was found for episodic priming. As was already noted, the results of this experiment indicated that neither sentence generation, nor the use of newly learned vocabulary words are factors that played a role in the absence of semantic learning in the previous experiments.

CHAPTER 3

LEARNING NEW SEMANTIC ASSOCIATIONS II: REPETITION OF PRIME-TARGET PAIRS IN PERCEPTUAL IDENTIFICATION AND PAIRED-ASSOCIATE LEARNING

Abstract - In four experiments (no. 4, 5, 6 and 7) semantic and episodic learning in a perceptual identification task was examined. In each experiment there were basically three stimulus conditions, with a) preexperimentally related prime-target pairs (SEM condition), b) preexperimentally unrelated prime-target pairs (EPIS condition) and c) neutral prime-target pairs (NEU condition). It was investigated whether repetition and paired-associate learning are sufficient conditions for the forming of a semantic association between a preexperimentally unrelated prime and target. In none of the experiments evidence was found for semantic learning. However, the results of Experiments 6 and 7 indicated effects of episodic learning. In these experiments, after prime-target pairs had been repeatedly presented in a learning phase, the studied prime-target pairs, preexperimentally related and unrelated, were facilitated relative to nonstudied prime-target pairs in a test phase. In three experiments (4, 5 and 7), the NEU condition consisted of changed pairs during the learning phase, i.e. after each presentation primes and targets were re-paired, but in none of the experiments episodic priming was found relative to this neutral condition, neither for the EPIS condition, nor the SEM condition.

3.1. Introduction

In the previous chapter evidence was found for episodic priming in lexical decision with newly learned associations (Experiments 1 and 2) and with preexperimental associations (Experiment 2). There was no indication of semantic learning.

One problem with lexical decision experiments is that it is a relatively indirect way to assess automatic priming. The decision process needed to perform this task complicates the interpretation of these studies, because decision biases can affect the results (Durgunoglu & Neely, 1987). To give an illustration of such a bias (see also section 2.2.3), suppose that word and nonword targets are presented in a lexical decision task, and that all the word targets were studied, and all the nonword targets were nonstudied in an earlier learning phase. As a consequence, a subject could use the information concerning the target's study status in order to make a 'word' or 'nonword' response in the lexical decision task. More specifically, a subject might then be biased to respond with 'word' or 'nonword' if the target was 'studied' or 'nonstudied' respectively.

Given the problem of decision biases in lexical decision, it seems more likely that tasks that restrict the influence of decision biases to occur, would facilitate the interpretation of the results. A word task in which the target has to be identified and named is a better candidate. Thus, in order to validate the episodic priming effects of the previous lexical decision experiments we ran additional experiments, this time however with a perceptual identification task. Evett and Humphreys (1981) used a perceptual identification task with a four-field procedure in which they demonstrated the semantic priming effect. In the four-field procedure the presentation of a prime word and target word is preceded and followed by a mask, resulting in the sequence: MASK - PRIME - TARGET - MASK. Evett and Humphreys found that masked target words were more likely to be correctly identified when they were preceded by a semantically related prime word than when they were preceded by a semantically unrelated prime word. This semantic priming effect in perceptual identification has also been found by other investigators (Rouse & Verinis, 1962; Marohn & Hochhaus, 1987). An important aspect of the procedure used by Evett and Humphreys was that the subjects were unaware of the identity of the prime, because it was masked by the target. With respect to the lexical decision task, it has been generally accepted that an identification response is not necessary for the semantic activation of the prime and its subsequent influence on the processing of the target (Allport, 1977; Marcel, 1983; Fowler, Wolford, Slade & Tassinary, 1981; Neely, 1992; Hirshman & Durante, 1992; but see also Holender, 1986, for a different view). Prime masking is useful for our experiments, because the prime-target pairs are repeated. If we want to repeatedly present prime-target pairs in a perceptual identification task, then it must be prevented that the identification of a target word can be predicted through knowledge of the prime's identity.

The purpose of the experiments reported in this chapter was to investigate whether perceptual identification is a reliable method for the detection of learning effects, and if so whether it would replicate the learning effects (i.e. semantic, repetition and episodic priming) that we found in the previous experiments with lexical decision. Moreover, where we failed to find evidence for semantic learning in lexical decision, it might be found in perceptual identification.

In order to investigate the addition of newly learned associations to semantic memory, the design of the experiments was similar to those of the previous experiments. Prime-target pairs were repeatedly presented in the perceptual identification task. There were three conditions that were also used in the previous experiments with lexical decision, namely SEM, EPIS and NEU. In the SEM condition the prime and target are preexperimentally related while in the EPIS condition the prime and target are preexperimentally unrelated. The pairings of the prime and target in these conditions were kept intact over the course of an entire experiment. In the NEU condition the prime and target are also preexperimentally unrelated, but the target word is preceded by a different prime on each repetition. Therefore we also refer to the NEU condition as the 'changed pairs' condition. The important difference between the EPIS condition and the 'changed pairs' condition is that in the former an association can be established between the prime and target word, but not in the latter because the pair is not kept intact.

As for the lexical decision experiments we expected the following facilitative priming effects in the perceptual identification task. In all conditions the performance is expected to improve due to a word repetition effect. However, if an association between the prime and target in the EPIS condition is formed the performance in this condition is expected to improve more than in the NEU condition. Eventually, after several repetitions the performance in the EPIS condition may reach the performance in the SEM condition. So if a semantic association between prime and target is formed, we expect to see an interaction between the EPIS and the NEU condition on the one hand, and between the EPIS and the SEM condition on the other hand, over a number of repetitions. If no interaction is observed between the EPIS and the SEM condition, then there is no evidence that a semantic association has been established between the prime and target word. The paradigm also enables us to study the effect of repeating preexisting semantic associations. We expect an interaction between the NEU condition and the SEM condition. Because we use the same preexperimentally related prime-target pairs in the SEM condition as in the lexical decision experiments, we assume that an interaction will be due to an episodically based association and not to a strenghtening of the semantic association.

3.2. Experiment 4

The aim of Experiment 4 was to investigate whether the four-field paradigm of Evett and Humphreys (1981) constitutes a reliable method for the detection of learning effects. Prime-target pairs were repeatedly presented in perceptual identification without explicit instruction to study the pairs.

In contrast to the lexical decision experiments, we limited the number of presentations of prime-target pairs and repeated them only five times. The reason is that Salasoo, Shiffrin and Feustel (1985) found learning effects with the perceptual identification of words and pseudowords with as few as five presentations (see section 1.5.1).

3.2.1. Method

3.2.1.1. Subjects

The subjects were 20 employees from the TNO Institute for Human Factors at Soesterberg, the Netherlands. There were 3 female and 17 male subjects, and their mean age was 29.1 years (*SD* = 8.1). All subjects reported normal or corrected-to-normal vision and were native speakers of Dutch.

3.2.1.2. Stimuli and apparatus

The subjects were tested individually in a normally lit room. All stimuli were presented on a Hewlett Packard digital display module, model 1345A. The screen was situated about 60 cm in front of the subject just below eye level. Stimulus presentation and response collection were controlled by a IBM Personal Computer.

The display consisted of a row of eight characters (letters and/or pattern mask characters). The primes were presented in lowercase and the targets in uppercase letters. Ten different pattern mask characters were constructed, each consisting of seven randomly oriented lines.

Each character covered a visual angle of approximately 0.9° horizontally and 0.6° vertically. The spacing between the centers of the characters was 0.3°. Thus the total field subtended a visual angle of about 6.7°.

The stimulus material consisted of a list of 75 semantically related prime-target pairs selected from De Groot's (1980) word association norms. There were three groups of 25 pairs each, balanced for word frequency and word length. One group formed the SEM condition, and consisted of semantically related prime-target pairs. Another group contained re-pairings of prime-target combinations, so that the prime and target where semantically unrelated. This was the EPIS condition. The last group also contained re-pairings and these formed the NEU condition. Two lists were constructed, with the stimulus material in the EPIS and NEU conditions on one list reversed on the other list. Subjects were randomly assigned to one of the two lists. A complete listing of the stimuli is given in Appendix B (page 141-143).

The experiment consisted of five presentation blocks. Each presentation block contained all 75 prime-target pairs, so that each prime and target were repeated five times. The order of presentation of the pairs within blocks was randomised. Over presentation blocks the prime-target pairs of the SEM and EPIS conditions were kept unchanged, and those of the NEU condition were re-paired on each presentation.

3.2.1.3. Procedure

Stimulus presentation was based on the four-field paradigm of Evett and Humphreys (1981). In this procedure a sequence of four stimuli is presented on each trial: The first and fourth stimuli are pattern masks, the second and third stimuli are words. The pattern masks were used in order to impede the perception of the prime and target. In our experiment each trial was preceded by a fixation point, so that a single trial consisted of the following sequence: Fixation point - forward mask - prime - target - backward mask. The targets were always in uppercase and the primes always in lowercase. This ensured that primes were always overlapped by the targets. The fixation point, the forward mask and backward mask were presented 700 ms each. The presentation time for the prime and the target was equal, and determined individually for each subject (see below).

The stimulus words were centered in a field of eight positions. Word length varied from three to eight letters. When the stimulus word consisted of less than eight letters, the remaining positions were filled with mask characters. These masks were randomly chosen from a set of 10 different mask characters. Within a trial a position was occupied by the same mask character for each of the four different stimuli.

The subjects made verbal responses on each trial and were asked to identify any words they thought had been presented. If not sure, they were asked to guess the identity of the presented words. The experimenter recorded on line whether the prime and target were correctly identified or not. A response was scored as correct only if the whole word was correctly identified; responses that only resembled the prime or target phonetically or orthographically were scored as incorrect.

The subjects received 10 practice trials after they had read an instruction about the perceptual identification task. Before the main experiment started each subject received a series of 50 treshold trials. In this test phase stimulus words were presented with the following durations: 22, 28, 34, 40 and 46 ms. Ten trials were given for each of the five stimulus durations. In these threshold trials only semantically unrelated prime-target pairs

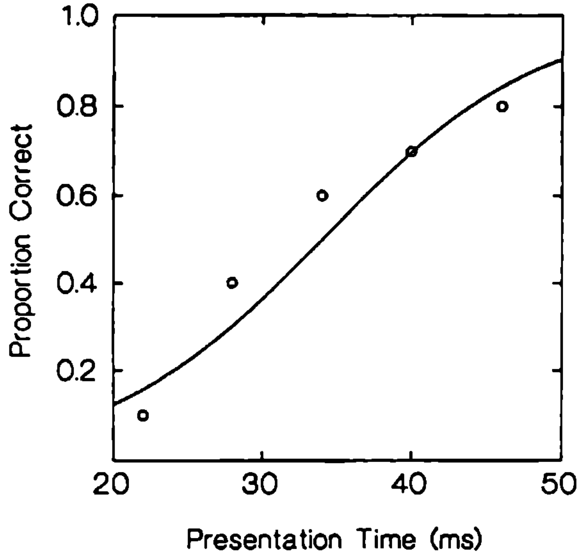

Figure 3.1. Best fit of the logistic function to the psychometric function of subject T.V. in Experiment 4.

were presented. The logistic function was used to fit the psychometric function for each subject separately[1]. The parameters of the logistic function were used to estimate the stimulus duration at which a subject would correctly identify the target in 40% of the presentations. This computed presentation time was used during the entire experiment. As an illustration, in Figure 3.1 the best fit of the logistic function to the psychometric function of subject T.V. in Experiment 4 is shown.

[1] Often the cumulative normal has been used to theoretically represent the psychometric function. A similar, but mathematically simpler function, is the logistic function (Bush, 1963). By relating proportion correctly identified targets P to presentation time t, the psychometric function then has the following form: $P = X/(1+X)$, with $X = \exp(a+bt)$, where a and b are the parameters. By choosing the logit form for P we find that: $\text{logit}(P) = \log[P/(1-P)] = a + bt$.

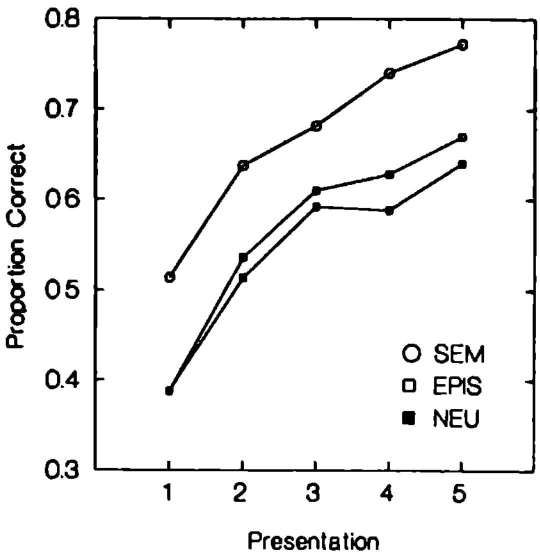

Figure 3.2. Proportion correctly identified targets in the perceptual identification task of Experiment 4 as a function of prime-type (SEM, EPIS and NEU) and presentation number.

3.2.2. Results

None of the subjects identified more than 8% of the primes on Presentation 1. The mean presentation time for the prime and target, as determined by the threshold procedure, was 35.9 ms (*SD* = 3.1).

The proportions correctly identified targets for the SEM, EPIS and NEU conditions were calculated for each subject and these were submitted to statistical analysis. An overall, three-way ANOVA was performed, with group (two list presentations) as between-subjects factor and prime type (SEM, EPIS and NEU) and presentation (five presentations) as within-subjects factors. Figure 3.2 displays the proportion correctly identified targets for the SEM, EPIS and NEU conditions as a function of presentation number. As can be seen, identification improves as a function of repetition in all conditions. Further, the identification in the SEM condition is superior to the identification in the other conditions. The data in Figure 3.2 suggest an interaction between the prime type and presentation factor, with the EPIS condition being facilitated more than the NEU condition with increasing presentation number. The results of the statistical analysis indicated that the main effect of presentation was significant ($F(4,72) = 62.70$, $p < .001$), as was the main effect of prime type ($F(2,36) = 47.79$, $p < .001$), but the interaction between both factors was not significant ($F < 1$). Thus, in Experiment 4 there was a significant difference between the SEM condition and the EPIS and NEU conditions. However the latter two conditions did not differ significantly. The main effect of group did not reach significance, nor its two-way interaction with presentation and its three-way interaction with prime type and presentation. The only significant interaction was between group and prime type ($F(2,36) = 24.80$, $p < .001$), which indicated that stimulus lists for the EPIS and NEU conditions were not perfectly matched.

3.2.3. Discussion

The target words in the SEM condition were identified correctly more often than the targets in the other two conditions. This is a replication of the results found by Evett and Humphreys (1981), and shows that semantic associations facilitate word identification (semantic priming). Also, the correct identification of targets increased with repetitions for all conditions.

There was however no interaction between prime type and presentation, and this implies that there was no evidence for episodic priming in the EPIS and SEM conditions, and no evidence that the new associations in the EPIS condition were added to semantic memory. The results suggest that the improvement in performance in all conditions was caused by repetition priming.

Our conclusion then is that the perceptual identification task constitutes a reliable method for detection of semantic and repetition effects. But the repetition of prime-target pairs is not a sufficient condition for episodic priming in this task. Because the primes and targets in Experiment 4 were presented at threshold level this may be the reason that subjects could not create associations between the words. This is a difference with Experiment 1, where the prime-target pairs were repeatedly presented in lexical decision and where an effect was found for episodic associations in the EPIS condition. Although in the lexical decision task each prime was presented for only 100 ms, this is long enough for identifying the word and this may be sufficient to associate it with the target word.

Thus, in order to stimulate the forming of an association we repeated the same experiment, but additionally, after a subject had made an identification response, feedback was given and the prime-target pair was shown for five seconds.

3.3. Experiment 5

The previous experiment showed that repetition of prime-target pairs is not sufficient to produce episodic priming. In Experiment 5 each repetition of a prime-target pair in the perceptual identification task was followed by feedback. Subjects were then instructed to learn the prime-target pair for a cued recall test to be administered at the end of the experiment. The purpose of Experiment 5 was to investigate whether paired-associate learning results in episodic priming, and additionally semantic learning, in a perceptual identifation task.

3.3.1. Method

3.3.1.1. Subjects

The subjects were 20 students at the Faculty of Social Sciences of the University of Leiden. Thirteen of these were female and seven were male. The mean age of the subjects was 22.5 years (*SD* 3.5). All subjects reported normal or corrected-to-normal vision and were native speakers of Dutch. The subjects were all paid for participating in the experiment.

3.3.1.2. Stimuli and apparatus

Stimulus presentation and apparatus were identical to that of Experiment 4. The only difference was the manner in which the stimulus material was assigned to the SEM, EPIS and NEU conditions. In the previous experiment the results indicated that the matching of the stimulus material in the word target conditions was imperfect. Therefore in Experiment 5 (but also in the following experiments) we changed the procedure for assigning the stimulus material to conditions. A master file was constructed that contained 75 related prime-target pairs. For each subject separately, 25 related prime-target pairs were randomly chosen from this file and used for the SEM condition in the experiment. For the 50 remaining pairs the prime-target pairings were randomly changed so that they formed 50 unrelated pairs. Twenty-five of these pairs were randomly selected to serve as stimuli in the EPIS condition. These pairs remained intact during the entire experiment. The last 25 prime-target pairs were assigned to the NEU condition ('changed pairs'). The pairing of these primes and targets was randomly changed for each presentation block. A complete list of the stimuli used is given in Appendix B (page 155).

3.3.1.3. Procedure

The procedure was basically the same as in the previous experiment. Only deviations from the procedure in that experiment are described. Directly after an identification response to the presentation of the prime-target pair, the pair was displayed again on the screen for five seconds. The subjects were instructed to form an association between the prime and target, by making a mental image or a sentence connecting both words. The subjects were told that they would be tested for their memory of the learned pairs at the end of the experiment.

After the five presentation blocks in perceptual identification, the subjects were tested for their cued recall of the targets in the SEM and EPIS conditions. The prime was shown on the screen for two seconds. The subjects were required to name the target to which the prime was paired during the experiment. The subjects were given as much time as they needed for giving their response.

3.3.2. Results

3.3.2.1. Perceptual identification

None of the subjects identified more than 8% of the primes in the first presentation block. The mean presentation time of the primes and targets was 37.4 ms (*SD* = 4.3). For each subject the proportion correctly identified targets in each condition was computed. These were submitted to statistical analysis.

In Figure 3.3 the proportions correctly identified targets for the SEM, EPIS and NEU conditions are shown as a function of presentation number. As can be seen, targets are identified best in the SEM condition. In addition, identification improves as a function of repetition in all conditions, except for the EPIS condition from Presentation 4 to 5, where there is a decrease in performance. First, an overall, two-way ANOVA was performed with prime type (SEM, EPIS and NEU) and presentation (five presentations) as within-

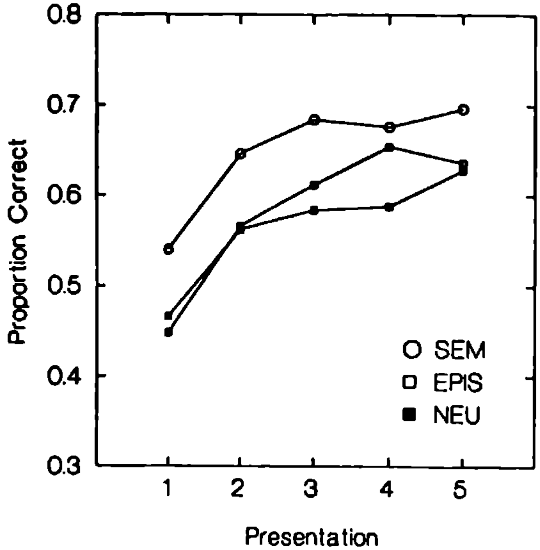

Figure 3.3. Proportion correctly identified targets in the perceptual identification task of Experiment 5 as a function of prime-type (SEM, EPIS and NEU) and presentation number.

subjects factors. The main factors of prime type ($F(2,38) = 9.13$, $p < .001$) and presentation ($F(4,76) = 27.23$, $p < .001$) were both significant. The interaction between both factors was not significant. In addition, an ANOVA was performed for the first four presentations only, to see whether this produced results that differed from the ANOVA for all five presentations. In this analysis prime type and presentation remained significant, with $F(2,38) = 10.89$, $p < .001$ and $F(3,57) = 26.97$, $p < .001$ respectively. The interaction between both factors was again not significant.

3.3.2.2. Cued recall

After the last presentation block in the perceptual identification task a cued recall test was administered. The mean proportion recalled targets in the SEM and EPIS conditions were (with the standard deviation between parentheses) .97 (.03) and .66 (.29) respectively, and the difference between both conditions was significant with $t(19) = 5.21$, $p < .001$.

3.3.3. Discussion

The results of Experiment 5 are basically the same as those of the previous experiment. As in Experiment 4, performance increased with repetitions and the target words in the SEM condition were identified better than the target words in the two other conditions. The most important finding is that there is again no statistically significant interaction between prime type and presentation. Even when the prime-target pairs are studied there is no evidence of episodic priming in the SEM an EPIS condition, and no evidence of the formation of a new semantic relationship between a preexperimentally unrelated prime and target. The suggestion by McKoon and Ratcliff (1986) that episodic priming is obtained whenever semantic priming is obtained is certainly not true for priming in a perceptual identification task.

The most likely interpretation of the results of Experiment 5 is that paired-associate learning does not seem to be sufficient for episodic priming and not sufficient for semantic learning, at least not with five presentations. Another possible interpretation of the present results is that there was more repetition priming in the NEU condition as compared to the other conditions. This is very unlikely, because we expect that repetition priming is independent of prime-type. Targets in the NEU condition were presented as often and received the same amount of feedback as the targets in the other conditions. A third possible interpretation is that, although it was prevented that a direct associative link could be formed between the prime and target in the NEU condition, it is possible that there was still a facilitative effect of the prime as a context cue. If a prime is studied on the same list as a target but not directly paired to it then it can still have a facilitative effect. This effect, that has been obtained earlier in lexical decision by Smith, MacLeod, Bain & Hoppe (1989), is referred to as the list-wide priming effect. Smith et al. found in two experiments that when a studied prime preceded a studied target, *regardless* of whether the prime-target pair was unchanged or re-paired, subjects responded about 30 ms faster than when a new (extralist) prime preceded an old target. There was no further advantage when a prime came from the same studied pair (unchanged) versus from a different pair (re-paired). Clearly, list-wide priming is a type of episodic priming. However, the hypothesis that there was list-wide priming in the NEU condition of our Experiment 5 has one difficulty, if it is assumed that the primes in the SEM and EPIS conditions can also have facilitative effects as context cues. Then it has to be explained that context cues in the NEU condition give better facilitation than the primes in the SEM and EPIS conditions.

Remember that we also failed to find evidence for episodic priming in Experiment 3, where the neutral condition also consisted of changed pairs. So our conclusion is that when the changed pairs condition is not a true neutral condition, the detection of episodic priming is obscured.

3.4. Experiment 6

The purpose of Experiment 6 was similar to Experiments 4 and 5, but we changed its design in order to have an additional method for detecting priming effects. We compared the identification of prime-target pairs repeated five times to the identification of prime-target pairs for which we changed the prime-target combination on the fifth presentation. All the targets on the fifth presentation were presented equally often, so they were matched with respect to the magnitude of repetition priming. The repeated prime-target pairs of the SEM condition were then compared to related prime-target pairs presented only once. Similarly, the repeated prime-target pairs of the EPIS condition were compared to unrelated prime-target pairs presented only once. If there is any effect of an association learnt during the experiment then this should result in improved identification of repeated pairs in contrast to pairs presented only once, other things being equal, like repetition priming and strength of the preexperimental association. So in Experiment 6 each type of studied prime-target relationship, related or unrelated, now had its own neutral condition.

3.4.1. Method

3.4.1.1. Subjects

The experiment was partially carried out in the laboratory of the TNO Institute for Human Factors, in Soesterberg, with 25 students of the University of Utrecht and 5 inhabitants of Soesterberg participating as subjects. In addition a part of the experiment was run at the University of Nijmegen, with 5 students of the Department of Psychology participating as subjects. All subjects had normal or corrected to normal vision and were native speakers of Dutch. The subjects were paid or fullfilled course requirements for their participation in the experiment. There were 22 female and 8 male subjects. The mean age of these subjects was 23.0 years (*SD* = 4.5).

3.4.1.2. Stimuli and apparatus

Stimulus presentation and apparatus were identical to the previous experiment. To the master file as described in the method section of Experiment 5, five new related prime-target pairs were added, resulting in a total sum of 80 pairs. The new pairs are listed in Appendix B (page 145-146). In addition to the extended master file an extra list with 20 primes was constructed (see also Appendix B).

From the master file, for each subject 20 prime-target pairs were randomly chosen for the SEM condition. For the remaining 60 pairs, prime-target pairings were randomly changed and these pairs were added to the EPIS condition. All 80 prime-target pairs were presented four times for perceptual identification. This constituted the learning phase of the experiment. There was no NEU condition in the learning phase.

The fifth presentation was the critical phase in which we performed our main manipulations. At this presentation the prime-target pairs vary across three experimental factors. The first factor is whether the prime and the target are preexperimentally related or unrelated. We call this factor the semantic status of the pair. The second factor is whether the prime and target were studied during the learning phase. We refer to this factor as the episodic status of the pair. The third factor indicates whether the prime and target was paired to on the fifth presentation, is a prime that was paired to another target during the learning phase of the experiment (intralist prime), or whether the prime is new and was not seen earlier during the experiment (extralist prime). This factor will be called the prime status of the pair.

On the basis of these three experimental factors, six conditions of prime-target pairings were constructed. These are depicted in Table 3.1. In the two columns at the right-hand side of this table the five presentations of prime-target pairs in the learning phase (Trial 1-4) and the test phase (Trial 5) are shown. The A symbolizes the prime and B the target. If these symbols have the same index, then this denotes that the prime and target are semantically related, otherwise not.

Condition 1 consists of 20 semantically related prime-target pairs that were randomly chosen from the master file. These pairs are presented five times. Thus, the prime-target pairs in this condition are semantically (+) and episodically (+) related. The prime-target pairing is left unchanged on the fifth presentation.

Condition 4 consists of 20 randomly chosen semantically unrelated prime-target pairs. Like the pairs in Condition 1, these pairs are presented five times. Therefore the pairs are

Table 3.1.
The Six Conditions of Experiment 6. These Conditions Vary Across Three Experimental Factors. See Text for Explanation.

Condition	Semantic status	Episodic status	Prime status	Trial 1-4	Trial 5
1	+	+	unchanged	A1-B1	A1-B1
2	+	-	intralist	A4-B2	A2-B2
3	+	-	extralist	A2-B3	A3-B3
4	-	+	unchanged	A8-B4	A8-B4
5	-	-	intralist	A6-B5	A9-B5
6	-	-	extralist	A9-B6	A7-B6

Experimental factors

Note. A = Prime; B = Target.

semantically unrelated (-), but episodically related (+). Again, a target is not re-paired to a new prime.

Conditions 2, 3, 5 and 6 each consist of 10 randomly chosen unrelated prime-target pairs. These pairs are presented four times. On the fifth presentation each target in these conditions is re-paired to a prime that was either presented earlier during the previous four presentations (intralist prime), or re-paired to a prime that was not seen earlier during the experiment (extralist prime).

In Conditions 2 and 3 the re-pairing of the target results in a semantic association, however in Condition 2 with an intralist prime and in Condition 3 with an extralist prime. The re-pairing in Conditions 5 and 6 results in prime-target pairs that are not semantically related (-), but in Condition 5 the targets are re-paired to intralist primes and in Condition 6 with extralist primes. Note that all conditions, 1 through 6, are matched with respect to the magnitude of repetition-priming. All targets in all conditions were presented five times.

By contrasting the appropriate conditions we assess the effects of semantic, episodic and prime status. The semantic priming effect can be revealed by any contrast between conditions that match with respect to episodic and prime status, but that differ with respect to semantic status (see Table 3.1). For instance we can contrast Conditions 1 and 4 that were both studied during the learning phase and thus have the same episodic and prime status (both equal to +), but not the same semantic status as Condition 1 consists of related pairs and Condition 4 consists of unrelated pairs.

The effect of studying a prime-target pair during the experiment, i.e. episodic priming, can be revealed by contrasting conditions that have the same semantic status but that differ with respect to episodic status. Episodic priming with semantically related prime-target pairs can be revealed by contrasting Conditions 1 and 2 or by contrasting Conditions 1 and 3. In the same vein, episodic priming with semantically unrelated prime-target pairs can be shown by contrasting Conditions 4 and 5 or by contrasting Conditions 4 and 6.

Lastly, in order to find out if there is an effect of studied, related or unrelated, primes we can contrast Conditions 2 and 3, and Conditions 5 and 6 respectively. The conditions in these contrasts match with respect to the factors semantic and episodic status, but differ with respect to prime status.

3.4.1.3. Procedure

Basically, the procedure is identical to the procedure of Experiment 5. After each identification response, the prime-target pair was shown again for five seconds. Subjects were not instructed to explicitly study the pair for a later cued recall test. After four trials subjects were given a cued recall test for all 80 prime-target pairs. The pairs were presented in random order.

3.4.2. Results

3.4.2.1. Perceptual identification

Learning phase. Subjects that identified more than 8% primes on the first presentation were excluded from further analyses. This resulted in a sample of 20 subjects. The mean presentation time of the primes and targets in this group was 38.5 ms (SD = 5.0). The relatively high proportion of recognized primes may be due to imprecise measurement of the true threshold presentation time. Figure 3.4 shows the proportion correctly identified targets separately for the SEM and the EPIS conditions on Presentation 1 through 4. The

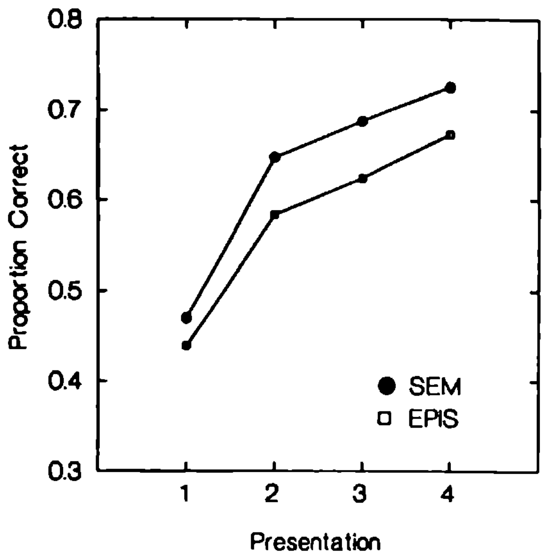

Figure 3.4. The learning phase of Experiment 6. Proportion correctly identified targets in the perceptual identification task as a function of prime-type (SEM and EPIS) and presentation number.

SEM condition contains the prime-target pairs of Condition 1, and the EPIS condition those of the Conditions 2 through 6. On the data of this figure a two-way ANOVA with prime type (SEM and EPIS) and presentation (four presentations) as within-subjects factors was performed. The main effects of prime type ($F(1,19) = 6.81$, $p < .02$) and presentation ($F(3,57) = 48.59$, $p < .001$) were both significant. The interaction between prime type and presentation was not statistically significant. During the learning phase there was no NEU condition, so it is not known for sure whether the increase in performance in both the SEM and the EPIS condition is due to episodic or repetition priming, or both. Nonetheless, there is no indication for semantic learning.

Test phase. First we tested whether there would be any difference in correct identification between targets re-paired to old primes (intralist) and targets re-paired to new primes (extralist) on the fifth presentation. This means that for semantically related pairs we had to compare Condition 2 with Condition 3, and for unrelated pairs we had to compare Condition 5 with 6. Figure 3.5 displays the proportion correctly identified targets

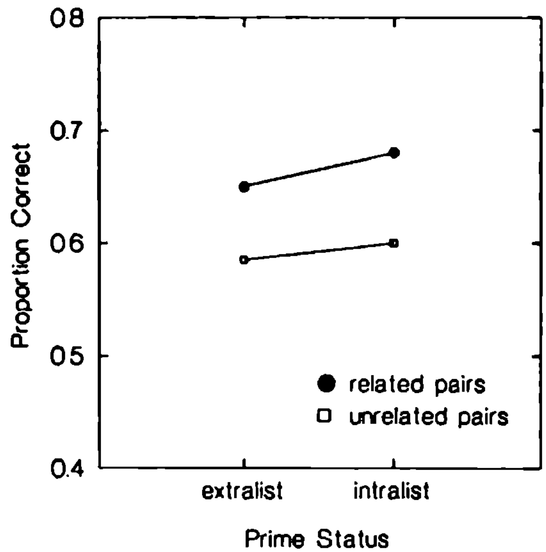

Figure 3.5. The test phase of Experiment 6. Proportion correctly identified targets in the perceptual identification task as a function of prime status (extralist and intralist prime) and semantic status (related and unrelated pairs).

on Presentation 5 as a function of prime status and semantic status. It can be seen that targets preceded by semantically related primes are identified better than targets preceded by semantically unrelated primes. But there is no difference in identification between targets preceded by intralist primes and targets preceded by extralist primes. We performed a two-way ANOVA with prime status (intralist and extralist) and semantic status (semantically related and unrelated) as within-subjects factors. The main effect of semantic status was only marginally significant ($F(1,19) = 3.75$, $.05 < p < .10$), and the main effect of prime status was not significant, nor was the interaction between both factors. Because there was no significant effect of prime status, in the following analyses the data from Conditions 2 and 3 are combined, as well as those from Conditions 5 and 6.

To assess whether there was episodic priming for the learned associations of Condition 1 (SEM) and Condition 4 (EPIS), we contrasted these conditions with the combined Conditions 2 and 3 and the combined Conditions 5 and 6 respectively. Figure 3.6 shows the proportion correctly identified targets as a function of semantic and episodic status. The figure suggests that there is a semantic priming effect, but also a strong effect of

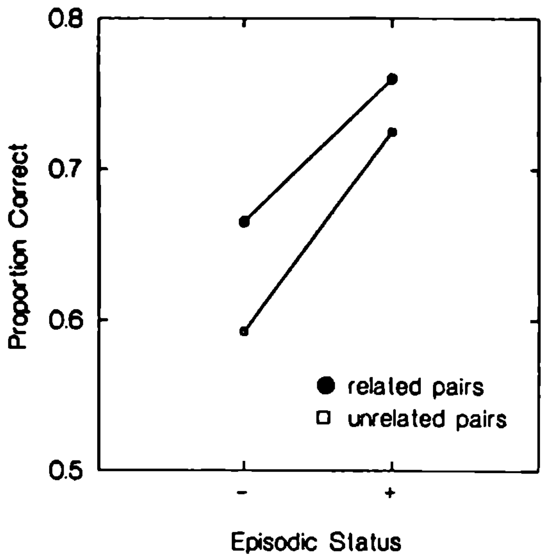

Figure 3.6. The test phase of Experiment 6. Proportion correctly identified targets in the perceptual identification task as a function of episodic status (-/+) and semantic status (related and unrelated pairs).

episodic priming for both types of learned associations. A two-way ANOVA was carried out with semantic status (semantically related and unrelated) and episodic status (-/+) as within-subjects factors. The main effect of semantic status was marginally significant ($F(1,19) = 4.10$, $.05 < p < .10$), indicating the semantic priming effect. The main effect of episodic status was highly significant ($F(1,19) = 17.29$, $p < .002$), thus confirming the indicated episodic priming effect in Figure 3.6 statistically. The interaction between semantic and episodic status was not significant. This means that the effect of episodic status is of the same magnitude in Condition 1 and 4, but also that the newly learned associations were not added to semantic memory.

3.4.2.2. Cued recall

After the fourth presentation block in perceptual identification a cued recall test was administered for all 80 prime-target pairs in the six conditions. Remember that subjects had not been explicitly instructed to study the pairs, and therefore the test was unexpected.

Table 3.2.
Proportion Recalled Targets in the Six Word Target Conditions at the End of the Learning Phase of Experiment 6.

	Word target condition					
	1	2	3	4	5	6
Cued recall	.90	.19	.31	.23	.22	.25
SD	.12	.15	.28	.18	.22	.23

Note. *SD* = Standard Deviation.

In Table 3.2 the proportions correctly recalled targets in the six conditions are displayed. Cued recall of the targets preceded by semantically related primes was best ($F(1,19) = 418.58$, $p < .001$). The targets in the remaining conditions were all preceded by semantically unrelated primes, and the recall performance in these conditions was approximately equal, except for Condition 3 where recall was slightly better ($F(1,19) = 6.46$, $p < .025$).

3.4.3. Discussion

In Experiment 6 we have, for the first time, found evidence for episodic priming in the perceptual identification task. The magnitude of the effect was similar for the SEM and EPIS conditions. However, there was no indication that a new semantic relationship had been learned between a prime and target that were preexperimentally unrelated. The effects of episodic and semantic status were additive.

The effect of episodic status was not the result of any strategic component. In that case we would have expected that an intralist prime, that was re-paired to a new target on the fifth presentation, showed an interference effect on target identification as compared to an extralist prime. But we did not find any effect of prime status, i.e. there was no difference between Conditions 2 and 3 and between Conditions 5 and 6. This also indicated that there is no effect of list-wide priming with a studied prime, because otherwise we should have observed that the identification of targets preceded by intralist primes (Conditions 2 and 5) was facilitated in comparison to targets preceded by the extralist primes (Conditions 3 and 6). The similar effects of intralist and extralist primes in Experiment 6 thus suggests that there was also no effect of list-wide priming in the changed pairs condition of Experiment 5. The alternative explanation that the list-wide priming effect is balanced by an equally strong interference effect, does not seem to be likely.

The reason for the difference in the results between Experiment 6 and 5 concerning the episodic priming effect is not clear. But there is one methodological aspect that could account for the difference. In Experiment 5, the changed pairs condition was used as a baseline condition for assessing episodic and semantic priming effects. In that experiment the subjects experienced that during every presentation some of the prime-target combinations were changed. In Experiment 6 only during the fifth presentation prime-target combinations were changed and this may have puzzled the subjects somewhat, leading to inhibition in Conditions 2, 3, 5 and 6. This issue was investigated in a next experiment.

3.5. Experiment 7

The design of Experiment 7 was a combination of the designs of Experiments 5 and 6. The design of the learning phase was similar to that of Experiment 5. To the presentation of preexperimentally related (SEM) and unrelated prime-target pairs (EPIS), a condition with changed prime-target pairs (NEU) was added. Adding a changed pairs condition to the learning phase should familiarize subjects with the fact that after each presentation some prime-targets were changed. So, in contrast to Experiment 6, if targets are re-paired on the fifth presentation this will not come as a surprise to the subject.

3.5.1. Method

3.5.1.1. Subjects

The subjects in Experiment 7 were selected from the subject pool of the TNO Institute for Human Factors in Soesterberg and were paid for their participation. There were 19 female and 11 male subjects. Mean age was 22.2 years (SD = 3.0). All subjects reported normal or corrected-to-normal vision and were native speakers of Dutch.

3.5.1.2. Stimuli and apparatus

To the master file of Experiment 6 an extra number of 26 semantically related prime-target pairs were added, resulting in a total of 106 pairs. The extra pairs are shown in Appendix B (page 146-147). Assignment of prime-target pairs to the experimental conditions took place in the same way as in Experiment 6. In the learning phase of the experiment, 14 semantically related prime-target pairs were randomly chosen from the master file for the SEM condition. Of the remaining 92 pairs the primes and targets were randomly re-paired. Of these, 42 were randomly selected for the EPIS condition, 24 were randomly selected for the changed pairs or NEU condition, and of the remaining 26 pairs the primes were used for the extralist prime conditions on the fifth presentation. On this presentation the targets of the SEM, EPIS and NEU conditions were assigned to the 10 conditions that varied across the experimental factors of semantic, episodic and prime status. In Table 3.3 these conditions are shown. Note that the Conditions 1 through 6 are the same as those of Experiment 6. The difference between Experiment 7 and 6 is that there are now four extra Conditions, 7 through 10, as a result of the addition of the changed pairs (NEU) condition. In Table 3.3, in the two columns at the right-hand side, the A symbolizes the prime and the B the target. Further, if the A and the B have the same index, then this denotes that the prime and target are semantically related, otherwise they are semantically unrelated.

The 14 semantically related prime-target pairs of the SEM condition remained unchanged from the learning to the test phase, and constituted Condition 1 (semantic status = +, episodic status = +, prime status = unchanged). The 42 targets of the EPIS condition, that were presented during the learning phase, were assigned to Conditions 2 through 6. Condition 4 contained 14 targets with unchanged primes (semantic status = -, episodic status = +). To each of the remaining conditions (2, 3, 5 and 6), seven targets were added and these were all re-paired to new primes (prime status = changed). On the fifth presentation we also manipulated the 24 targets of the changed pairs (NEU) condition. All targets were re-paired to new primes (prime status = changed). The targets were added to four conditions each having six targets. The four conditions varied with respect to semantic relationship and whether the new prime was intralist or extralist. Of course, none of the prime-target pairs in these conditions were episodically associated (episodic status = -), because during the learning phase the targets were in the changed pairs condition. Prime-target pairs in Conditions 7 and 8 were semantically related

Table 3.3.
The 10 Conditions of Experiment 7. These Conditions Vary Across Three Experimental Factors. See Text for Explanation.

	Experimental factors				
	Semantic status	Episodic status	Prime status	Trial	
Condition				1-4	5
1	+	+	unchanged	A1-B1	A1-B1
2	+	-	intralist	A4-B2	A2-B2
3	+	-	extralist	A2-B3	A3-B3
4	-	+	unchanged	A8-B4	A8-B4
5	-	-	intralist	A6-B5	A9-B5
6	-	-	extralist	A9-B6	A7-B6
7	+	-	intralist	NEU	NEU
8	+	-	extralist	NEU	NEU
9	-	-	intralist	NEU	NEU
10	-	-	extralist	NEU	NEU

Note. A = Prime; B = Target.

(semantic status = +) and the primes in these conditions were intralist and extralist respectively. The prime-target pairs in Conditions 9 and 10 were semantically unrelated (semantic status = -), with the primes being intralist and extralist respectively.

Because the design of the learning phase in Experiment 7 is a replication of the design of Experiment 5, we do not expect episodic priming on the first four presentations. On the fifth presentation we again investigate the effects of episodic associations by contrasting those conditions that have the same semantic status, but a different episodic status. The Conditions 2, 3, 5 and 6 are the neutral conditions, i.e. any facilitative effect of episodic associations in Conditions 1 and 4 is measured in relation to these conditions. In addition, the Conditions 7, 8, 9 and 10 are also neutral. The difference is that the targets in these conditions are from the changed pairs condition in the learning phase, instead of from the EPIS condition.

The apparatus is the same as in the previous experiments.

3.5.1.3. Procedure

The procedure with respect to practice trials, threshold trials and experiment proper is the same as in the Experiments 4, 5 and 6. At the beginning of the first presentation block during the learning phase, subjects were instructed to study the prime-target pairs for a later cued recall test. This test was administered at the end of the fourth presentation, and its procedure was as in the previous experiment.

3.5.2. Results

3.5.2.1. Perceptual identification

Learning phase. Only the results of subjects that identified less than 9% of the primes on the first presentation of the learning phase were used for statistical analysis. This left a total of 21 subjects. Mean presentation time of the primes and targets, as determined in the threshold procedure, for this group of subjects was 36.1 ms (SD = 4.3). In Figure 3.7 the proportion correctly identified targets in the SEM, EPIS and NEU (changed pairs) condition are displayed as a function of number of presentations. As can be seen in this figure, targets are identified best in the SEM condition. Further, in all conditions identification improves with repetition. There is no indication of episodic priming for the EPIS condition, but with number of presentations the performance in the SEM condition improves more than in the NEU condition. An overall, two-way ANOVA with prime type (SEM, EPIS and NEU) and presentation (four presentations) as within-subjects factors was performed. The main factors of prime type and presentation were both significant with respectively $F(2,40) = 21.38$, $p < .001$ and $F(3,60) = 50.28$, $p < .001$, but their interaction was not, which indicates that there was no effect of episodic priming in the EPIS condition, nor in the SEM condition.

Test phase. First, it was investigated whether there were any differences between intralist and extralist primes concerning identification performance for a) targets that were studied in the EPIS condition during the learning phase (Conditions 2, 3, 5 and 6) and b) targets that were studied in the changed pairs or NEU condition during the learning phase (Conditions 7, 8, 9 and 10). The results are shown in Figure 3.8. The data in this figure

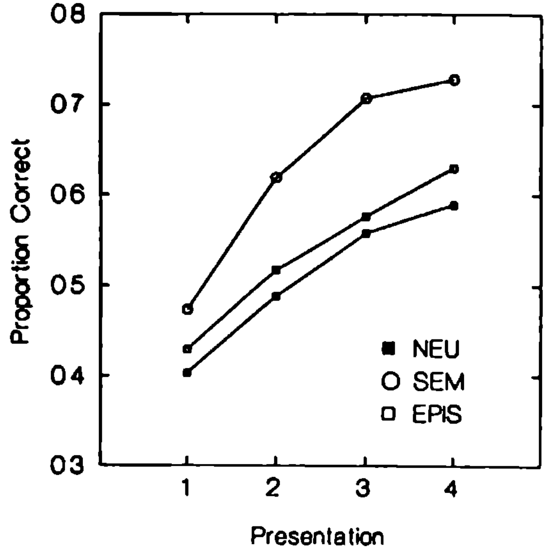

Figure 3.7. The learning phase of Experiment 7. Proportion correctly identified targets in the perceptual identification task as a function of prime-type (SEM, EPIS and NEU) and presentation number.

show that there are small differences between the conditions. We performed separate two-way ANOVAs with semantic status (semantically related and unrelated prime-target pairs) and prime status (intralist and extralist) as within-subjects factors, for the targets in the EPIS and NEU conditions respectively. The results for the EPIS condition were that both main factors, semantic status and prime status, and their interaction were not significant. The same results were found for the NEU condition. Thus, targets preceded by intralist and extralist primes were identified equally well, and this was true both for targets studied in the EPIS condition and targets studied in the NEU condition during the learning phase. In the following analyses conditions with intralist and extralist primes were combined, but only for the targets of the EPIS condition. Next we investigated whether the learned associations, semantically related or unrelated, showed episodic priming. First, we contrasted the Conditions 1 and 4 with the combined Conditions 2 and 3, and the combined Conditions 5 and 6 respectively. In Figure 3.9 these contrasts are shown. As is suggested by the figure, there is a much larger episodic priming effect for the semantically related prime-target pairs than for the unrelated pairs. We performed a two-way ANOVA

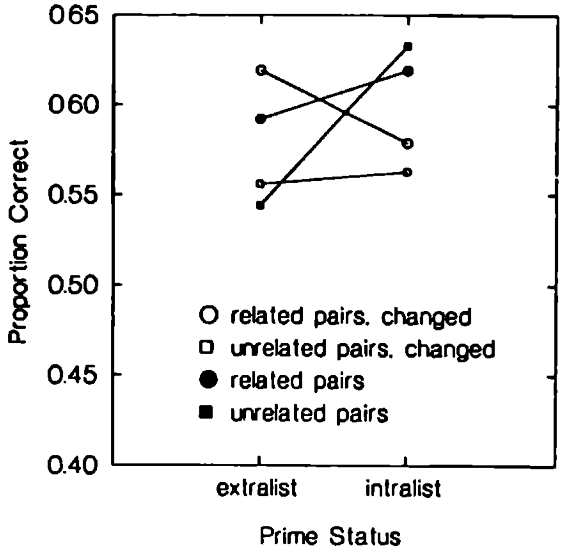

Figure 3.8. The test phase of Experiment 7. Proportion correctly identified targets in the perceptual identification task as a function of prime status (extralist and intralist prime) and semantic status (related and unrelated pairs). The factor semantic status contains targets that were presented earlier in the EPIS and NEU (changed pairs) conditions during the learning phase of Experiment 7.

with semantic status (semantically related and unrelated) and episodic status (-/+) as within-subjects factors on the data of Figure 3.9. The main effects of semantic status ($F(1,20) = 6.60$, $p < .02$) and episodic status ($F(1,20) = 11.57$, $p < .004$) were both statistically significant, but the interaction between them was not ($F(1,20) = 2.00$, $p > .17$).

3.5.2.2. Cued recall

After the fourth presentation block of the perceptual identification task in the learning phase, the cued recall test was given. In Table 3.4 the proportions correctly recalled targets for the six word target conditions are shown. Again the targets that were preceded by semantically related primes (Condition 1) were recalled best ($F(1,20) = 25.87$, $p < .001$). Recall performance in the remaining (EPIS) conditions was similar ($F(4,80) =$

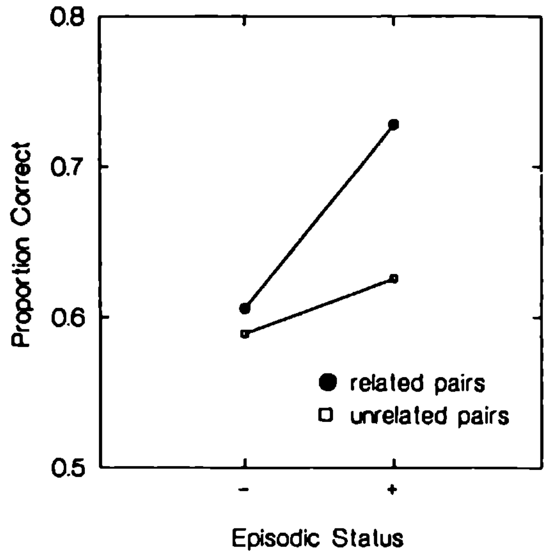

Figure 3.9. The test phase of Experiment 7. Proportion correctly identified targets in the perceptual identification task as a function of episodic status (-/+) and semantic status (related and unrelated pairs).

1.44, $p > .22$). Note that the performance in this test is better than in the cued recall test of the previous experiment (see Table 3.2). The difference is probably due to the fact that in the present experiment the subjects were explicitly instructed to study the prime-target pairs, whereas in the previous experiment they were not.

3.5.3. Discussion

Experiment 7 again demonstrated an episodic priming effect in the test phase for the learned associations, semantically related and unrelated. The results were similar to those of Experiment 6. The difference between both experiments is that in Experiment 7 a NEU condition was added to the learning phase, with the purpose to familiarize the subjects to the prime-target pairs being changed. The conclusion is that it is very unlikely that the manipulation of familiarisation plays a role in the detection of episodic priming effects in the perceptual identification task. The absence of episodic priming in the learning phase of Experiment 7 is a replication of Experiment 5.

Table 3.4.
Proportion Recalled Targets in the Six Word Target Conditions at the End of the Learning Phase of Experiment 7.

	Word target condition					
	1	2	3	4	5	6
Cued recall	.96	.68	.76	.69	.70	.65
SD	.07	.34	.26	.25	.32	.28

Note. *SD* = Standard Deviation.

As was the case with the previous experiments in this chapter, there was again no evidence found for semantic learning in the perceptual identification task.

3.6. General discussion

The four experiments described in this chapter showed that the four-field procedure for presenting prime-target pairs in the perceptual identification task is a reliable method for investigating episodic and semantic learning effects.

With respect to episodic learning in the perceptual identification task, it was found that repetition (four presentations only) of prime-target pairs and feedback, without instruction to study for cued recall, were sufficient conditions for episodic priming of targets in the EPIS and SEM conditions. However, the effect was found only when repeated prime-target pairs were compared to targets preceded by re-paired (intralist and extralist) primes during a test phase (Experiment 6). It is unlikely that unfamiliarity with changed prime-target pairs played a role in the measurement of the episodic priming effect (Experiment 7).

In the perceptual identification task, contrasting the repeated pairs of the EPIS and SEM conditions with the changed pairs of the NEU condition during the four presentations of the learning phase, revealed no episodic priming, even when subjects were explicitly instructed to study the prime-target pairs for later cued recall (Experiments 5 and 7).

As was the case in the experiments described in Chapter 2, we again did not find any evidence that the newly learned associations were added to semantic memory.

CHAPTER 4

LEARNING NEW SEMANTIC ASSOCIATIONS III: TRANSFER OF LEARNING EFFECTS BETWEEN SEMANTIC MEMORY TASKS

Abstract - In three experiments (no. 8, 9 and 10) it was investigated whether learning effects would transfer between semantic memory tasks. During a learning phase, word pairs being preexperimentally related (SEM condition) or unrelated (EPIS condition) were repeatedly presented as prime-target pairs in lexical decision and/or as stimulus-response pairs in paired-associate learning. During a test phase, the performance of studied and nonstudied prime-target pairs was always compared in two semantic memory tasks: Lexical decision and perceptual identification. In Experiments 8 and 9 no transfer of learning was found. That is, studied prime-target pairs, preexperimentally related and unrelated, were only facilitated relative to nonstudied pairs if the task environments during the learning and test phase were similar. This constituted evidence for context-dependent, episodic learning. In Experiment 10, only the studied prime-target pairs that were preexperimentally unrelated showed transfer of learning. This was an indication for context-independent, semantic learning. Further, during the learning phase of Experiment 10, the preexperimentally unrelated prime-target pairs were facilitated more than the preexperimentally related prime-target pairs in lexical decision. This constituted additional evidence for semantic learning.

4.1. Introduction

In order to explore the sufficient conditions for semantic learning we performed experiments with repetitions of prime-target pairs in a lexical decision task (Chapter 2) and a perceptual identification task (Chapter 3). Although in none of the experiments thus far any indication of semantic learning was found, we nevertheless found some variables that play an important role in episodic priming (see the general discussions in Sections 2.4 and 3.6).

The purpose of this chapter is two-fold. First, experiments are described in which we proceeded with exploring the variables that play a role in episodic priming. In one experiment it was investigated whether the design of Experiment 6 (Chapter 3) also leads to episodic priming in the lexical decision task. In Experiment 6, prime-target pairs of the EPIS and SEM conditions were repeatedly presented in the perceptual identification task during a learning phase. Then, in a consecutive test phase, the performance of studied prime-target pairs, semantically related and unrelated, was compared to the performance of a neutral condition, consisting of re-paired primes and targets, again in the perceptual identification task. It was found that the studied prime-target pairs were facilitated relative to the changed prime-target pairs. In Experiment 8, prime-target pairs were repeatedly presented for study in the lexical decision task during a learning phase. Then, in a following test phase, studied prime-target pairs were compared to changed prime-target pairs, not only in the lexical decision task, but also in the perceptual identification task. Presenting two tasks in the test phase was done for the following reason. If it should be found that studied prime-target pairs show episodic priming in lexical decision, we wondered whether this learning effect would also transfer to perceptual identification.

The design of Experiment 9 was similar to that of Experiment 8. Studies that demonstrated episodic priming effects (McKoon & Ratcliff, 1979, 1986; Durgunoglu & Neely, 1987), have always applied study trials with only paired-associate learning and without presentation of prime-target pairs in a semantic memory task, such as lexical decision or perceptual identification. Therefore, in Experiment 9 we repeatedly presented word pairs for paired-associate learning, but without presentation of these pairs as prime-target pairs in a semantic memory task. Then, in a consecutive test phase, we investigated whether the studied word pairs would lead to episodic priming effects in lexical decision and/or perceptual identification, by comparing them to changed pairs.

The second purpose of this chapter is to describe an experiment in which we continued to search for sufficient conditions for semantic learning. In Experiment 10, prime-target pairs were repeatedly presented for lexical decision and explicit study during a learning phase, under similar conditions as in Experiment 2 (see Chapter 2). In addition to the SEM, EPIS and NEU conditions, a new condition with preexperimentally weak associations was presented. The assumption is that weak associations already have links in semantic memory (Collins & Loftus, 1975; Anderson, 1983), and that strengthening these links is easier than forming completely new links, as is the case for preexperimentally unrelated words. If it can be shown that there is an interaction between the lexical decision times of preexperimentally weakly related prime-target pairs and those of preexperimentally strongly related prime-target pairs, with the former being facilitated more than the latter as a function of number of presentations, then we have evidence that two factors play a role in semantic learning. The first factor concerns the creation of a new semantic link between words, when that link is still nonexistent. The second factor concerns the strengthening of a semantic link between words, when that link is existent, but still weak.

The design of Experiment 10 was similar to that of Experiment 2. As noted, prime-target pairs were repeatedly presented for lexical decision and explicit study. But in Experiment 10 there were some procedural modifications of the design that was used in Experiment 2. In that experiment, after each block of lexical decision trials, the prime-target pairs of the SEM and EPIS conditions were again presented for paired-associate learning. A problem was that the prime-target pairs of the NEU condition were not presented for this paired-associate learning, and this might have led to less repetition priming for the targets of the NEU condition and consequently to an overestimation of the episodic priming in the SEM and EPIS conditions. In Experiment 10, after presentation of a prime-target pair for lexical decision and given that both the prime and target were words, the pair was shown again on the computer screen. The subject was then instructed to learn that both words belong together and that this would be tested later in the experiment. In contrast to Experiment 2, the targets of the NEU condition were presented also for paired-associate learning. After a lexical decision was made, the word prime *blank* was substituted by a new word; and the subject learned the combination of the NEU target and the new word. With this modification in the procedure of paired-associate learning there is more certainty about whether the episodic priming effect is a true learning effect, because the word targets of all the three conditions EPIS, SEM and NEU are matched with respect to the amount of repetition priming.

As was the case for Experiments 8 and 9, in Experiment 10 we also added a test phase, in which studied prime-target pairs were compared relative to changed pairs in lexical decision and in perceptual identification.

4.2. Experiment 8

4.2.1. Method

4.2.1.1. Subjects

The subjects were 15 females and 6 males selected from the subject pool of the TNO Institute for Human Factors in Soesterberg and were paid for their participation. The mean age of the subjects was 21.9 years (*SD* = 2.1). All subjects reported normal or corrected-to-normal vision and were native speakers of Dutch.

4.2.1.2. Design and Stimulus Materials

A master file containing 112 semantically related prime-target pairs was constructed. These related word pairs were selected from the norms provided by De Groot (1980). A complete listing of the master file is given in Appendix B (page 144-147). Each prime-target pair of the master file was assigned at random to one of the six conditions of the experiment. The unrelated conditions were obtained by changing the pairings of the prime-target pairs of the master file. All prime-target pairs, semantically related and unrelated, were kept unchanged during the first four presentations, which constituted the learning phase. After the first four presentations some of the prime-target pairs were re-paired and in addition all prime-target pairs, re-paired and unchanged, were presented two times during the test phase of the experiment. The re-pairing of prime and targets constituted the main manipulation, because it allowed an assessment of the episodic priming effect with prime-target pairs in the EPIS and SEM conditions. Our manipulations resulted in a design that is similar to that of Experiments 6 and 7. Because of its complexity we repeat the description of this design. There are three experimental factors in the design. The first factor indicates whether the prime and target are preexperimentally related (according to word association norms). This factor is referred to as the semantic status of the pair. The second factor concerns whether the prime and target were presented as a pair on the four presentations of the learning phase. This factor is called the episodic status of the pair. The last factor indicates the status of the prime that is paired to a target in the test phase, and is referred to as the prime status of the pair. Some primes were presented during the learning phase and these were paired to the same target as in the test phase (unchanged) or to another target (intralist). The remaining primes were new, and were not seen earlier during the experiment (extralist). The design with the three experimental factors is shown in Table 4.1. In the two columns at the right-hand side of this table, the prime-target pairs are shown that were presented during the learning (Trials 1-4) and test phase (Trial 5) of the experiment. The A symbolizes the prime and the B the target. If both the A and the B have the same index, then this denotes a preexperimental association between the prime and the target. Condition 1 was the SEM condition and consisted of 16 preexperimentally related prime-target pairs. The prime-target pairings remained unchanged after the first four presentations of the learning phase. Thus, the prime-target pairs in this condition are semantically and episodically related and the prime status is unchanged.

Condition 4 was the EPIS condition of the learning and test phase of the experiment,

Table 4.1.
An Overview of the Experimental Design of Experiment 8. See Text for Explanation.

Condition	Semantic status	Episodic status	Prime status	Trial 1-4	Trial 5
1	+	+	unchanged	A1-B1	A1-B1
2	+	-	intralist	A4-B2	A2-B2
3	+	-	extralist	A2-B3	A3-B3
4	-	+	unchanged	A8-B4	A8-B4
5	-	-	intralist	A6-B5	A9-B5
6	-	-	extralist	A9-B6	A7-B6

Note. A = Prime; B = Target.

and consisted of 16 preexperimentally unrelated prime-target pairs. As for Condition 1, the pairing was kept unchanged from the learning to the test phase of the experiment. So, the prime-target pairs in this condition are semantically unrelated, episodically related and the prime status is unchanged.

Conditions 2, 3, 5 and 6 each consisted of eight prime-target pairs that were all preexperimentally unrelated on the four presentations of the learning phase. These four conditions constitute the EPIS condition of the learning phase and the NEU conditions of the test phase. The prime-target pairings of these conditions were changed after the fourth presentation, so that all the prime-target pairs were episodically unrelated. The targets were re-paired to primes that were either presented earlier in the experiment, but paired to another target (intralist, Conditions 2 and 5), or with primes that were not seen earlier during the experiment (extralist, Conditions 3 and 6). Further, the re-pairing of primes and targets led to either semantically related prime-target pairs (Conditions 2 and 3) or to semantically unrelated prime-target pairs (Conditions 5 and 6). All the extralist primes came from 16 prime-target pairs selected at random from the master file. The targets of these pairs were not used in the experiment.

Condition 7, which is not depicted in Table 4.1., consisted of 32 nonword targets and 32 word primes. The nonwords used in Experiment 8 were a) Finnish words and selected from a Finnish-Dutch dictionary ('t Hooft, 1987) and b) pseudowords. Most Finnish and pseudowords resembled Dutch words orthographically. The nonword targets are listed in Appendix B (page 147). All primes came from 32 pairs selected at random from the master file. The targets of these pairs were not used. The primes and targets of Condition 7 were not re-paired after the fourth presentation.

The experimental design allows us to assess the effects of semantic and episodic priming, the effect of intralist versus extralist primes and of course the effect of semantic learning. The effects are tested by contrasting those conditions that differ with respect to only one experimental factor. Because the targets of all the six conditions were presented equally often, any differences between conditions cannot be due to differences in repetition priming. During the learning phase, the semantic priming effect can be tested by comparing Condition 1 (SEM) versus Conditions 2 through 6 (EPIS) on the first presentation. The semantic priming effect can be tested further by contrasting Conditions 1 and 4, Conditions 2 and 5, and Conditions 3 and 6 during the test phase. The effect of episodic priming in the SEM condition can be assessed by contrasting Condition 1 and Condition 2 or by contrasting Condition 1 and Condition 3. Similarly, the effect of episodic priming in the EPIS condition can be assessed by contrasting Conditions 4 and 5, or by contrasting Conditions 4 and 6. The effect of prime status, i.e. the effect of intralist versus extralist primes in the NEU condition, can be tested by contrasting Conditions 2 and 3 for semantically related prime-target pairs, and by contrasting Conditions 5 and 6 for semantically unrelated prime-target pairs. Finally, in order to assess whether there was any effect of semantic learning, i.e. the addition of the newly learned associations to semantic memory, Condition 1 (SEM) can be contrasted with Conditions 2 through 6 (EPIS) on the four presentations of the learning phase. Further, the difference between Condition 1 and Conditions 2 and 3 in the test phase can be contrasted with the corresponding difference between Condition 4 and Conditions 5 and 6.

4.2.1.3. Procedure

All word targets were presented six times in the experiment. In the learning phase each prime-target pair was presented four times in a lexical decision task. The learning phase ended with a cued recall test. Next, all targets were presented once in the lexical decision task and once in the perceptual identification task. These two presentations constituted the test phase of the experiment. One half of the targets was preceded by the same primes as they were paired to in the learning phase, the other half was preceded by other primes. In the test phase subjects were assigned randomly to two groups. One group of subjects performed the lexical decision task first and then the perceptual identification task, in the other group this order was reversed. Below, each phase of the experiment will be described in more detail.

Learning Phase. Subjects started with 24 practice trials in lexical decision at the beginning of the learning phase. Sixteen trials consisted of word targets and eight consisted of nonword targets. Following these trials a practice cued recall test was administered. In the learning phase of the experiment proper there were four presentation blocks of lexical decision trials. Each prime-target pair was presented once in each presentation block. There were a total of 96 presentations of prime-target pairs in each presentation block. Of these, 64 consisted of word targets, with 16 preceded by semantically related primes (SEM condition) and 48 preceded by semantically unrelated primes (EPIS condition). The remaining 32 prime-target pairs all consisted of nonword targets. The order of presentation of the 96 prime-target pairs within each presentation block was randomized.

An asterisk signalled the beginning of a new presentation of a prime-target pair in lexical decision. Next, somewhat below and to the right of the position of the asterisk, the prime was shown for 100 ms. After a blank screen of 40 ms the target was displayed, below and to the right of the position of the prime. The target was displayed until the subject responded with 'word' ('?/'-key) or 'nonword' ('Z'-key). After the subject made a response, feedback about accuracy and speed was given. If the response was correct and faster than 900 ms then GOED (correct) was shown on the computer screen. If the response was correct, but slower than 900 ms and faster than 2400 ms, then LANGZAAM (slow) was given as feedback. If the response was incorrect, independent of reaction time, then FOUT (incorrect) was shown to the subject. All responses, correct or incorrect, that were slower than 2400 ms were followed by TE LAAT (too late) as feedback. Additional feedback about speed of response was given by showing the reaction time in milliseconds. After the subject made a lexical decision, and given that both the prime and the target were words, they were again shown on the computer screen for five seconds. The subjects were instructed to learn that both words belong together and that their memory for them would be tested later in the experiment.

Cued recall test. Immediately after the learning phase of the experiment, subjects were tested for their memory of the learned prime-target pairs. In this test the prime was presented for 10 seconds on the computer screen. Subjects were instructed to write down the target with which the prime was presented during the learning phase of the experiment.

Test Phase. The next two presentations of prime-target pairs in the lexical decision and perceptual identification task constituted the test phase of the experiment. There were two presentation orders of the lexical decision and perceptual identification task (see above). The procedure for the lexical decision task in the test phase deviated from the procedure in the learning phase. One difference was that none of the prime-target pairs was presented again for paired-associate learning after a lexical decision had been made. Another difference was that the proportion semantically related and unrelated prime-target pairs was changed as a result of the re-pairing after the learning phase. In the test phase 32 pairs were semantically related and 32 pairs were semantically unrelated.

Before the perceptual identification task in the test phase was started, each subject first received 10 practice trials in order to get familiarized with the task. Next, each subject was given a series of 50 threshold trials in order to determine the presentation time of each prime and target. In these threshold trials only semantically unrelated prime-target pairs were presented. Each prime and target was presented for one of the following durations: 22, 28, 34, 40 or 46 ms. The proportion correct responses in 10 trials for each of the five durations served as the data for the psychometric function (see also section 3.2.1.3), that was used to estimate the threshold presentation time at which the subjects would correctly identify a target in 40% of the trials. Each estimated presentation time was rounded to the nearest multiple of 2 ms and then used as the presentation time for each prime and target in the experiment proper.

Presentation of a prime-target pair was based on the four-field procedure of Evett and Humphreys (1981). In this procedure a sequence of four stimuli is presented on each trial: The first and fourth stimuli are pattern masks, the second and third stimuli are words. The pattern masks are used in order to impede the seeing of the stimulus words. In Experiment 8 each trial was first preceded by a fixation point, so that a single trial consisted of the following sequence: Fixation point - forward mask - prime - target - backward mask. The fixation point, forward mask and backward mask were each presented for 700 ms. The presentation times of prime and target were equal and were set to the estimated threshold time. The prime was in lowercase and the target in uppercase, so that the target would overlap the prime.

The stimulus words were centred in a field of eight positions. Word length varied from three to eight letters. When a stimulus word consisted of fewer then eight letters, all remaining open positions were filled with mask characters. These were randomly chosen from a set of 10 different characters. Within a trial, a open letter position was occupied by the same mask character for each of the four stimuli in the sequence.

The 32 nonword targets that were used for lexical decision, were not presented in the perceptual identification task. The 64 word targets and their primes that were presented in the lexical decision task were all presented, in random order, in the perceptual identification task. Subjects made verbal responses on each trial and were asked to name any words they thought they had seen. It was stressed that they should make a guess if they were unsure about the identity of the presented words. The experimenter recorded on line whether a response, prime or target, was correct or not. A response was scored as correct only if the complete word had been named correctly; responses that resembled a presented word phonetically or orthographically were scored as incorrect. After a subject had made an identification response the prime-target pair was presented again for five seconds. Subjects were instructed that it was not required to learn the prime-target pair.

4.2.1.4. Apparatus

Lexical Decision. For this task an IBM Personal Computer was used. Measurement of reaction times was controlled by a Turbo Pascal (version 4.0) software timer written by Brysbaert, Bovens, D'Ydewalle and Van Calster (1989).

Perceptual Identification. All stimuli in this task were presented on a Hewlett Packard digital display module, model 1345A. The screen was situated about 60 cm in front of the subject just below eye level. Stimulus presentation and response collection were controlled by an IBM Personal Computer. Each display of a stimulus consisted of a row of eight characters (pattern masks and letters). Each character covered a visual angle of approximately 0.9° horizontally and 0.6° vertically. The spacing between the centres of the characters was 0.3°. Thus the total field subtended a visual angle of about 6.7°.

4.2.2. Results

4.2.2.1. Lexical decision

In the lexical decision task only reaction times longer than 150 ms and shorter than 900 ms were submitted to statistical analysis. For each subject mean reaction times were calculated in each word target condition in the learning (EPIS and SEM) and test phase (Conditions 1 through 6). We performed our statistical analyses on these mean reaction times. Because for each subject a random selection of the stimulus material from a master file was made, we only performed subject-analyses (see Appendix A, page 126).

Learning phase: Reaction time data. In Figure 4.1 the lexical decision times to word targets in the EPIS and SEM conditions as a function of number of presentations in the learning phase are depicted. It can be seen in this figure that the lexical decision times in both conditions are getting faster from Presentation 1 to Presentation 4. Because there was

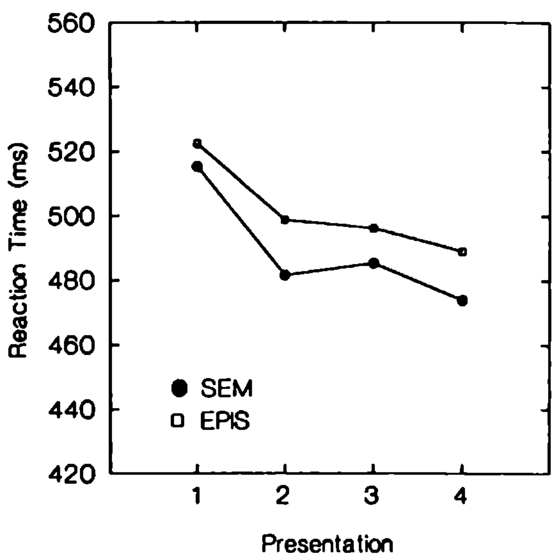

Figure 4.1. The learning phase of Experiment 8. Reaction times (in milliseconds) in the lexical decision task as a function of prime type (SEM and EPIS) and presentation number.

Table 4.2.
Error Percentages in the SEM and EPIS Conditions as a Function of Presentation Number During the Learning Phase of Experiment 8.

	Presentation			
	1	2	3	4
SEM	2.1	1.5	0.6	1.2
EPIS	3.7	2.2	1.2	1.8

no neutral condition in the learning phase, it is not known with certainty whether the decreasing reaction times are a result of repetition priming, of episodic priming or of both. Further, as can be seen in Figure 4.1, the lexical decision times in the SEM condition are faster than those in the EPIS condition on all presentations, and the difference does not become smaller with an increasing number of presentations. Thus there is no indication of semantic learning. A three-way ANOVA with group (presentation order of the lexical decision and perceptual identification task in the test phase) as between-subjects factor, and prime type (SEM and EPIS) and presentation (four repetitions) as within-subjects factors was carried out. The main factor of group ($F < 1$) was not significant, nor was its interaction with the other factors. The main factors of prime type ($F(1,19) = 12.65$, $p < .003$) and presentation ($F(3,57) = 5.24$, $p < .004$) were significant, but the interaction between both factors ($F < 1$) was not.

Learning phase: Error data. An error was scored whenever a subject made a wrong keypress, i.e. responded with 'nonword' when a 'word' response was required. In Table 4.2 the error percentages for the SEM and EPIS conditions in the lexical decision task are shown, as a function of presentation number during the learning phase. Remember that the EPIS condition consists of the Conditions 2 through 6. As can be seen in Table 4.2, less errors were made in the SEM condition ($F(1,20) = 3.39$, $.05 < p < .10$).

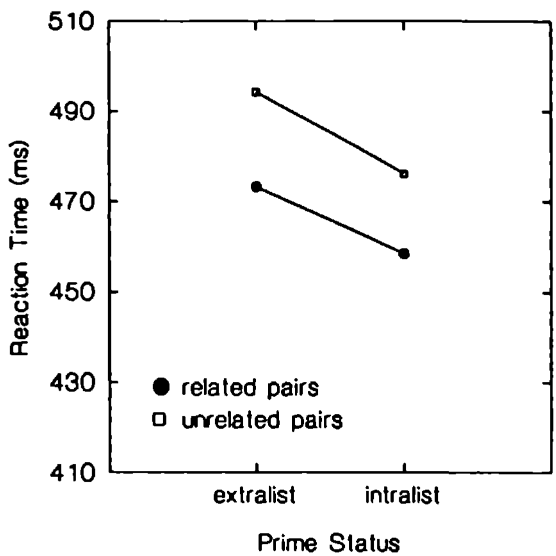

Figure 4.2. The test phase of Experiment 8. Reaction times (in milliseconds) in the lexical decision task as a function of prime status (extralist and intralist prime) and semantic status (related and unrelated pairs).

Test phase: Reaction time data. First we analyzed whether there was any difference between word targets (semantically related and unrelated) that were re-paired to intralist primes (Conditions 2 and 5) and those that were re-paired to extralist primes (Conditions 3 and 6). As can be seen in Figure 4.2, lexical decision times are faster if word targets are preceded by intralist primes than if they are preceded by extralist primes. Also, lexical decision times are faster if the prime-target pairs are semantically related in contrast to prime-target pairs that are semantically unrelated. This constitutes the semantic priming effect with changed prime-target pairs. A three-way ANOVA with group (presentation order of the lexical decision task in the test phase) as between-subjects factor and prime type (semantically related and unrelated) and prime status (intralist and extralist) as within-subjects factors was performed on the data of Figure 4.2. There was no significant effect of group ($F(1,19) = 2.14$, $p > .15$), but both prime type ($F(1,19) = 6.25$, $p < .025$) and prime status ($F(1,19) = 10.27$, $p < .006$) reached significance. None of the interactions were significant. In the next analysis, the Conditions 2 and 5 with intralist primes where chosen as NEU conditions to contrast them respectively with the Conditions

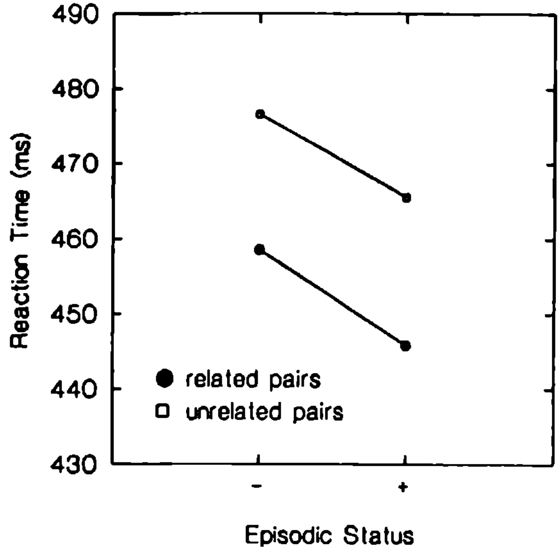

Figure 4.3. The test phase of Experiment 8. Reaction times (in milliseconds) in the lexical decision task as a function of episodic status (-/+) and semantic status (related and unrelated pairs).

1 (SEM) and 4 (EPIS) in order to find out whether there were any learning effects. In Figure 4.3 these contrasts are shown. Lexical decision times to prime-target pairs that were studied in the learning phase (episodic status = +) are faster when contrasted with lexical decision times to changed prime-target pairs (episodic status = -), and also, lexical decision times are faster when the prime-target pairs are semantically related. For statistical analysis a three-way ANOVA with group as between-subjects factor, and prime type and episodic status (-/+) as within-subjects factors was performed. The main effect of group was not significant ($F(1,19) = 1.39$, $p > .25$), but there were significant main effects of prime type ($F(1,19) = 16.46$, $p < .002$) and episodic status ($F(1,19) = 4.60$, $p < .05$). None of the interactions reached significance.

Test phase: Error data. The error percentages in the lexical decision task were 1.9, 3.8, 3.0, 1.2, 0.0 and 4.2 for the Conditions 1 through 6 respectively.

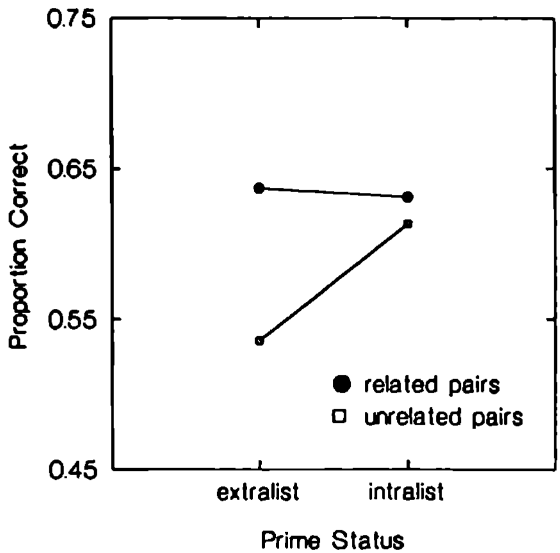

Figure 4.4. The test phase of Experiment 8. Proportion correctly identified targets in the perceptual identification task as a function of prime status (extralist and intralist prime) and semantic status (related and unrelated pairs).

4.2.2.2. Perceptual identification

The perceptual identification task was only performed in the test phase of the experiment. Overall, the mean presentation time of a prime and target was 39.1 ms (SD = 4.5). For each subject the proportion correctly identified targets in the six word target conditions of the test phase were computed and these were all submitted to subject-analyses (see Appendix A, page 126).

In Figure 4.4 the proportions correctly identified targets in the four conditions (2, 3, 5 and 6) with re-paired primes (intralist and extralist) are shown. Although there is no difference in identification between semanticallly related targets that are paired to intralist and extralist primes, it seems that semantically unrelated targets that are paired to intralist primes are identified better than those paired to extralist primes. To the data of Figure 4.4 a three-way ANOVA with group (presentation order of the perceptual identification task in the test phase) as between-subjects factor and prime type (semantically related and unrelated) and prime status (intralist and extralist) as within-subjects factors was performed

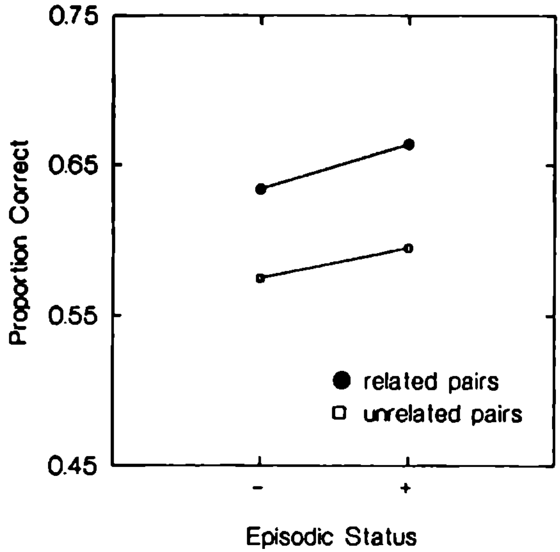

Figure 4.5. The test phase of Experiment 8. Proportion correctly identified targets in the perceptual identification task as a function of episodic status (-/+) and semantic status (related and unrelated pairs).

and none of the main effects reached significance at a standard alpha level. Of the interactions only the Group x Prime type interaction ($F(1,19) = 5.3$, $p < .035$) was significant. In our next analysis we collapsed Condition 2 with 3, and Condition 5 with 6. These constitute then the NEU condition with semantically related prime-target pairs and the NEU condition with semantically unrelated prime-target pairs, respectively. In Figure 4.5 the proportions correctly identified targets of these NEU conditions are shown together with those of Condition 1 (SEM) and Condition 4 (EPIS). It can be seen in this figure that the targets of the semantically related pairs are identified better than the targets of the unrelated pairs, indicating a semantic priming effect. But there is neither an indication of an episodic priming effect nor an indication of semantic learning. The targets in Condition 1 (episodic status = +, semantically related) are not identified better than the collapsed Conditions 2 and 3 (episodic status = -, semantically related), and the targets in Condition 4 (episodic status = +, semantically unrelated) are not better identified than the targets of the collapsed Conditions 5 and 6 (episodic status = -, semantically unrelated). We performed a three-way ANOVA on the data of Figure 4.5, with group as between-subjects

Table 4.3.
Proportion Recalled Targets With the Prime Given as Cue in the Six Word Target Conditions at the End of the Learning Phase of Experiment 8.

	Word target condition					
	1	2	3	4	5	6
Cued recall	.98	.76	.76	.75	.73	.73
SD	.04	.25	.26	.22	.26	.28

Note. *SD* = Standard Deviation.

factor and prime type and episodic status (-/+) as within-subjects factors. This statistical analysis resulted in only a significant main effect of prime type ($F(1,19) = 12.47$, $p < .003$). The other main effects of group and episodic status were not significant (Fs < 1). Of the interactions, only the Group x Episodic Status x Prime type interaction was significant ($F(1,19) = 6.15$, $p < .025$). Inspection of the results indicated that for subjects that received the perceptual identification task first, and then the lexical decision task, there was an indication of episodic priming in the SEM condition. For subjects that received the tasks in reversed order there was an indication of episodic priming in the EPIS condition. However, separate analyses for the group levels revealed that these episodic priming effects were not significant (Fs < 1).

4.2.2.3. Cued recall

In Table 4.3 the results of the cued recall test, that was given at the end of the learning phase, are shown. The targets in Condition 1 (SEM) were recalled best ($F(1,20) = 25.44$, $p < .001$). The proportions recalled targets in the remaining conditions (EPIS) were approximately equal ($F < 1$). These conditions all consisted of semantically unrelated prime-target pairs.

4.2.3. Discussion

The effects that were found in the perceptual identification task of Experiment 6, were replicated in the lexical decision task of Experiment 8. We again found a reliable effect of semantic priming, and more importantly, we also found a reliable effect of episodic priming in the SEM and EPIS conditions, although there was no indication that the newly learned associations in the EPIS condition were added to semantic memory. However, there is one result that deviates from what was found in Experiment 6. In the test phase of Experiment 8 it was found that targets preceded by changed, intralist primes had faster lexical decision times than targets preceded by changed, extralist primes. Thus it seems that target processing is facilitated by primes that were on the same list during the learning phase. This effect in lexical decision has been reported earlier by Smith, MacLeod, Bain and Hoppe (1989) and they referred to this effect as the list-wide priming effect. In five different study conditions they found that lexical decision times were approximately 25-30 ms faster for studied targets preceded by studied primes, unchanged or re-paired, in comparison to targets preceded by new, extralist primes. Smith et al. considered list-wide priming as a type of episodic priming, and not as some sort of general arousal engendered by studied primes, because the effect could not be found with new targets or nonword targets.

An interesting result of Experiment 8 is, further more, that the episodic priming effect that was found in the lexical decision task did not transfer to the perceptual identification task. This indicates that the episodic priming effect is context-dependent. Context-dependency, as was explained in Chapter 1, refers to the fact that a learning effect depends on the overlap between the environmental context of a study and test phase. The results in Experiment 8 suggest that if episodic associations are tested again in the same task environment as during the learning phase then there will be a facilitative learning effect, otherwise not. With task environment we mean that it includes the type of computer that is used for stimulus presentation, such as a normal size PC-screen or a small tachistoscopic display screen, but it also includes the manner how the prime-target pairs were presented in the lexical decision and perceptual identification task. Nelson and Jacoby (in Jacoby & Witherspoon, 1982) found that when items were presented with the same tachistoscope during study and test, there was a substantial learning effect in perceptual identification. However, there was no such learning effect when the items were presented with a slide projector for study, thus when the environmental context between study and test was varied. There is also evidence that learning effects are reduced if the type face of letters is changed from study to test (Kolers & Perkins, 1975; Kolers, Palef & Stelmach, 1980). In Experiment 8 the type face and color of letters differed between the lexical decision and perceptual identification task. In the former task both a prime and a target were presented as lowercase, orange-coloured letter strings, whereas in the latter task the prime was presented as a lowercase, green-coloured letter string and the target as an uppercase, green-coloured letter string. In conclusion then, the facilitative, automatic priming that we found with the learned associations in the lexical decision task, but not in the perceptual identification task, provides strong evidence for the assumption that these associations are episodic in nature.

The studies that have reported episodic priming effects (McKoon & Ratcliff, 1979, 1986; Durgunoglu & Neely, 1987) in the lexical decision task, always presented the to-be-learned associations as word pairs in a paired-associate task, but never as prime-target pairs in a semantic memory task during the learning phase of the experiment. In the next experiment we also presented the to-be-learned associations as word pairs in a paired-associate task only, and investigated the effects in the lexical decision and perceptual identification task during the test phase.

4.3. Experiment 9

4.3.1. Method

4.3.1.1. Subjects

From the pool of subjects of the TNO Institute for Human Factors in Soesterberg 22 subjects, 9 females and 13 males, were selected for Experiment 9. They were all paid for their participation. All of them had normal or corrected-to-normal vision. The mean age of the subjects was 21.3 years (*SD* = 1.5).

4.3.1.2. Design and Stimulus material

In Experiment 9 the same stimulus material and design was used as in the previous experiment.

4.3.1.3. Procedure

In the learning phase the 64 prime-target pairs of the Conditions 1 through 6 were presented as word pairs in four presentation blocks. presentation order in each block was randomized. All word pairs were shown on the screen of the HP display module. On a presentation, first a fixation point was shown and then the word pair for six seconds, with the prime in lowercase and the target in uppercase. The target was displayed below the prime. Subjects were instructed to learn both words as belonging together and to try to make a mental image of them. They were also told that later in the experiment all word pairs would be tested in a cued recall task. At the end of the fourth presentation block for paired-associate learning the cued recall test was given.

The procedure in the test phase was the same as in Experiment 8.

4.3.1.4. Apparatus

We used the HP display module for presentation of the word pairs in the paired-associate task (see also procedure). The apparatus that was used in the test phase for the lexical decision task and the perceptual identification task was the same as in Experiment 8.

4.3.2. Results

Because the design, stimulus material and procedure in the test phase of Experiment 9 are the same as in the test phase of the previous experiment, all the comments made there with respect to the statistical analyses also apply here.

4.3.2.1. Lexical decision

Reaction time data. The data of one subject were lost due to computer failure. This resulted in a total of 21 subjects for statistical analysis. In Figure 4.6 the lexical decision times of the changed, semantically related and unrelated, pairs with intralist and extralist primes are shown. The data in this figure suggest that semantically related pairs have faster lexical decision times than unrelated pairs. In addition, the data also indicate that there is a list-wide priming effect, i.e. targets preceded by intralist primes show facilitation

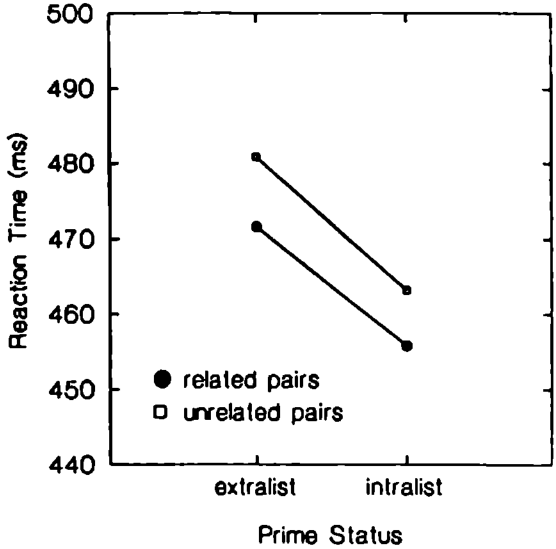

Figure 4.6. The test phase of Experiment 9. Reaction times (in milliseconds) in the lexical decision task as a function of prime status (extralist and intralist prime) and semantic status (related and unrelated pairs).

in contrast to targets preceded by extralist primes. We performed a three-way ANOVA on the data pattern of Figure 4.6, with group (presentation order of the lexical decision task) as between-subjects factor and prime type (semantically related and unrelated) and prime status (intralist and extralist) as within-subjects factors. The main effect of group was not significant ($F < 1$), nor was the main effect of prime type ($F(1,19) = 2.15$, $p > .15$). The main effect of prime status was significant ($F(1,19) = 8.06$, $p < .02$). None of the interactions were significant. Next we investigated whether there was an effect of episodic priming by contrasting the Conditions 1 (SEM) and 4 (EPIS) with the conditions containing changed intralist primes, these being Conditions 2 and 5 respectively. In Figure 4.7 the lexical decision times of these conditions are depicted. Not surprisingly, lexical decision times for the semantically related pairs are faster than those for the unrelated pairs, indicating a semantic priming effect. But the lexical decision times for pairs that were studied in the learning phase are slower than the pairs with changed primes that are intralist. We performed a three-way ANOVA with the between-subjects factor group and the within-subjects factors prime type and episodic status (-/+). The main effect of prime

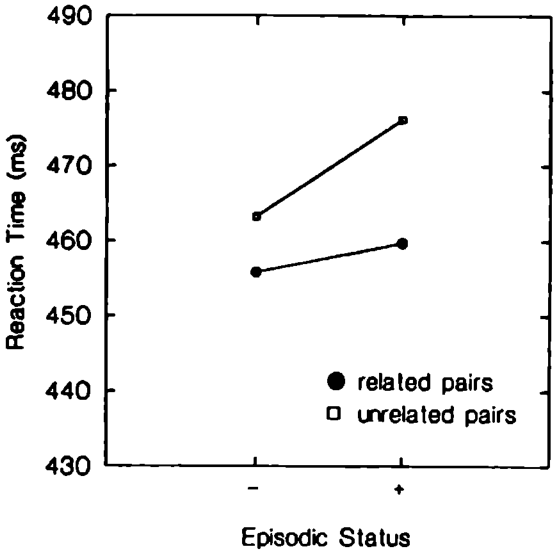

Figure 4.7. The test phase of Experiment 9. Reaction times (in milliseconds) in the lexical decision task as a function of episodic status (-/+) and semantic status (related and unrelated pairs).

type ($F(1,19) = 5.47$, $p < .04$) was significant, as was the main effect of episodic status ($F(1,19) = 7.21$, $p < .02$). The main effect of group ($F < 1$) was not significant. None of the interactions reached significance. Because there was a substantial difference between intralist and extralist primes, we repeated the same ANOVA with the extralist primes. This time only the main effect of prime type ($F(1,19) = 6.75$, $p < .02$) was significant, but not the main effects of episodic status ($F(1,19) = 1.78$, $p > .19$) and group ($F < 1$). The interactions were not significant.

Error data. The error percentages in the lexical decision task were 1.5, 1.2, 2.4, 1.8, 1.2 and 2.4 for the word target Conditions 1 through 6 respectively, and did not differ significantly in the statistical analysis (F < 1).

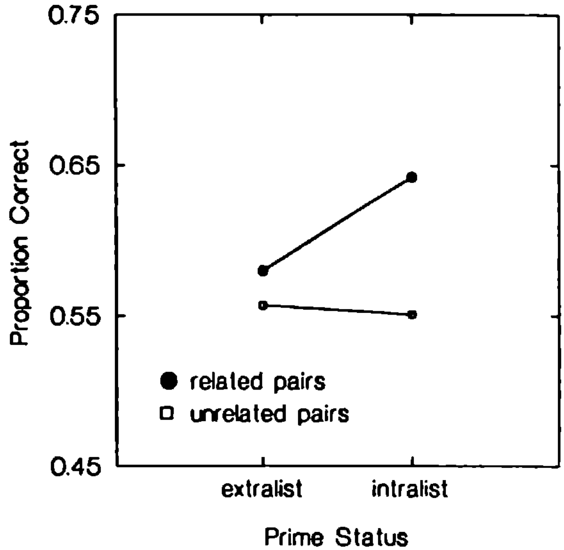

Figure 4.8. The test phase of Experiment 9. Proportion correctly identified targets in the perceptual identification task as a function of prime status (extralist and intralist prime) and semantic status (related and unrelated pairs).

4.3.2.2. Perceptual identification

The mean presentation time of a prime and target was 38.9 ms (*SD* = 5.1). The contrasts between intralist primes and extralist primes for semantically related and unrelated pairs are displayed in Figure 4.8 with respect to proportion correctly identified targets. Only for the related pairs there seems to be a difference in identification, but this was not confirmed by the three-way ANOVA with group (presentation order of the perceptual identification task) as between-subjects factor and prime type (semantically related and unrelated) and prime status (intralist and extralist) as within-subjects factors. None of the main effects and none of the interaction effects were significant. Because of these statistically nonsignificant results we collapsed Condition 2 with 3 and Condition 5 with 6. These collapsed NEU conditions were then contrasted with the Conditions 1 (SEM) and 4 (EPIS) respectively, both containing learned associations. The contrasts are shown in Figure 4.9. As expected, there is a difference between the semantically related and unrelated pairs. But more interestingly, there is also a difference between episodically

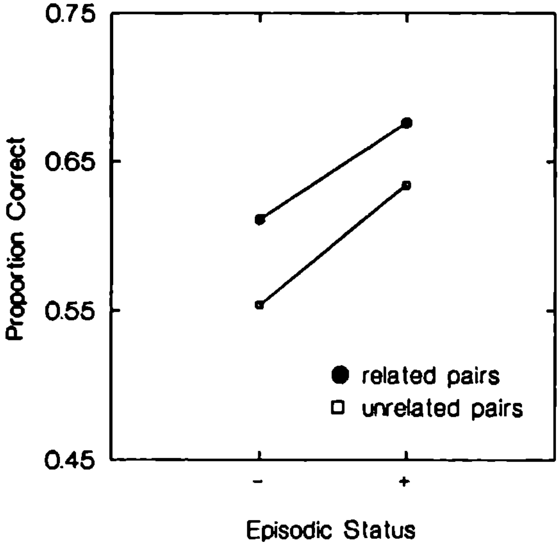

Figure 4.9. The test phase of Experiment 9. Proportion correctly identified targets in the perceptual identification task as a function of episodic status (-/+) and semantic status (related and unrelated pairs).

associated and changed prime-target pairs. We performed a three-way ANOVA with the between-subjects factor group and the within-subjects factors semantic status and episodic status (-/+). The group factor was not significant ($F < 1$), the factor semantic status only marginally ($F(1,20) = 3.85$, $.05 < p < .10$), and the factor episodic status was significant at the standard alpha level ($F(1,20) = 5.12$, $p < .04$). None of the interactions were significant. Thus the episodic priming in the perceptual identification task of Experiment 9 is statistically reliable. However, there is no indication that the newly learned associations of the EPIS condition were added to semantic memory.

4.3.2.3. Cued recall

The results of the cued recall test, that was given after the paired-associate task, are given in Table 4.4. It can be seen that again the targets of Condition 1, that are semantically related to their primes, are recalled best in comparison to those of the conditions with semantically unrelated primes ($F(1,20) = 20.31$, $p < .001$). Recall in the

Table 4.4.
Proportion Recalled Targets With the Prime Given as Cue in the Six Word Target Conditions at the End of the Learning Phase of Experiment 9.

	Word target contition					
	1	2	3	4	5	6
Cued recall	.97	.91	.88	.83	.89	.85
SD	.05	.12	.14	.16	.14	.20

Note. *SD* = Standard Deviation.

latter conditions is approximately the same, except for Condition 4, which has a somewhat lower level ($F(1,20) = 4.58$, $p < .05$). The overall level of recall in Experiment 9 is somewhat higher than in the previous experiment. This is probably due to the fact that the total study time was longer than in Experiment 8.

4.3.3. Discussion

In the present experiment again evidence has been found for the episodic priming effect in the SEM and in the EPIS condition. The interesting point is that in contrast to Experiment 8, there was episodic priming in perceptual identification, but not in lexical decision. Moreover, in the latter task the episodic associations were slower than the changed pairs.

Note that in Experiment 8 we explained episodic priming in lexical decision as a context-dependent effect. During the learning phase in that experiment prime-target pairs were repeatedly presented in the lexical decision task. Although in the present experiment the learning phase was task neutral, i.e. prime-target pairs were not repeatedly presented for perceptual identification or lexical decision, we still think that the episodic priming we have found now was also dependent on the context during study. The word pairs that were presented for paired-associate learning, were shown on the HP display module that was also used for the perceptual identification task, and they were also shown in the same type face and color as the prime-target pairs that were presented in the perceptual identification task.

No evidence of semantic learning was found.

4.4. Experiment 10

Until now we have established the conditions under which episodic priming occurs for newly learned associations and also for preexperimental associations. In the previous experiments we did not find any evidence for the formation of new semantic associations. In forming a new semantic association between two words that are preexperimentally unrelated, there are two aspects that might be distinguished during the process of learning. The first is the creation of a new link between the words when that link is not yet existent. The second aspect in the learning process is the consolidation of the link between the words, when the link has been formed but is still weak. One can imagine that more, and especially more elaborative learning is needed to create a completely new link, but once a link is created it is relatively easy to consolidate it and to raise the newly formed association, though still weak, to the level of a strong association. Our suggestion that there are two learning aspects in the creation of new semantic associations is based on the associative strength effect. This effect means that there is a positive relationship between the magnitude of the semantic or associative priming effect and the strength of the association between prime and target. There are several investigators who have reported data that refer to this effect (Fischler & Goodman, 1978; Becker, 1980; Seidenberg, Waters, Sanders & Langer, 1984; Cañas, 1990), but there are also investigators who have failed to find evidence of the effect (Neely, 1977; De Groot, Thomassen & Hudson, 1982; Koriat, 1981). The associative strength effect is an effect that is predicted by spreading activation models (Collins & Loftus, 1975; Anderson, 1983). In these models the strength of an association between two word nodes is conceived as the distance between the two word nodes or as the relative strength of the link between the two word nodes in semantic memory. If the distance between two word nodes is longer or the relative strength between them is smaller, then less activation spreads and consequently there is a smaller priming effect.

In order to investigate the role of two factors in semantic learning, i.e. forming a new semantic association and elaborating an existing, though weak semantic association, Experiment 10 was designed. As was the case in the previous Experiments 8 and 9, Experiment 10 consisted of two phases: A learning phase and a test phase. In the learning phase all prime-target pairs were repeatedly presented in the lexical decision task and most of these were also presented in the paired-associate task. During the same phase subjects were also tested for their explicit memory of the studied material by way of cued recall tests. In comparison to Experiments 8 and 9, two word target conditions were added to the learning phase, in addition to the SEM and EPIS conditions: One condition with semantically weakly related primes and one condition with neutral primes (*blank*). Further, all prime-target pairs were presented nine times instead of four times.

In the test phase all word targets of the learning phase were again presented in two semantic memory tasks: Lexical decision and perceptual identification. Some of the word targets in the test phase were preceded by the same primes as in the learning phase. These prime-target pairs constituted the learned associations. The other word targets were preceded by changed primes (intralist or extralist).

Thus, in Experiment 10 we could again test episodic priming in two phases. In the learning phase as well as in the test phase learned associations were contrasted with neutral conditions. In addition, during the test phase we could also assess whether a learning effect in the lexical decision task would transfer to the perceptual identification task, in order to investigate the role of context-dependency.

However, the main purpose of the experiment was to investigate whether the formation of a new semantic link or the strengthening of a weak semantic link is crucial in learning new semantic associations.

4.4.1. Method

4.4.1.1. Subjects

Twenty-seven subjects, all students from the University of Nijmegen, participated in Experiment 10. Mean age of the 7 male and 20 female subjects was 22.5 years (*SD* = 3.4). All subjects reported normal or corrected-to-normal vision and were native speakers of Dutch. Subjects were paid or received course credit for their participation.

4.4.1.2. Design and Stimulus Materials

Basically, in Experiment 10 a similar design as in the previous experiments was used, but there are also some important differences. Because in Experiment 10 two word target conditions were added, a new master file with stimulus material was constructed. This master file contained 91 word triplets. Every word triplet consisted of a word target, a semantically strongly associated prime and a semantically weakly associated prime. None of these appeared more than once in the word triplets. The word triplets were constructed according to the published word association norms of De Groot (1980), Lauteslager, Schaap and Schievels (1986) and Van Loon-Vervoorn & Van Bekkum (1991). Mean association frequency of the strongly related prime-target pairs in the word triplets was 48.2 (*SD* = 17.8) and the mean association frequency of the weakly related prime-target pairs was 2.9 (*SD* = 1.5). In Appendix B (page 148-153) all word triplets are shown. In addition to the master file with word targets a file with 28 nonword targets was constructed. The nonword targets consisted of Finnish words ('t Hooft, 1987) and pseudowords, all orthographically similar to Dutch words. For each subject, at the beginning of the experiment 63 word triplets were randomly chosen from the master file for use in the four word target conditions of the learning phase. Of this set of word triplets, 14 were selected for the condition with semantically strongly related primes, SEM-s; 14 were selected for the condition with semantically weakly related primes, SEM-w; and 14 were selected for the condition with semantically unrelated primes, EPIS. To the word triplets that were chosen for the latter condition, semantically unrelated primes from other word triplets had been added. The remaining word triplets (21) from the randomly chosen set of 63 were used for the neutral condition, NEU, in the learning phase of the experiment. All the word targets in this condition were paired to the neutral prime *blanco* (*blank*). The semantically strongly related primes from 20 of the remaining word triples in the master file were paired to 20 nonword targets. The remaining eight nonword targets were paired to the neutral prime *blanco* (*blank*). All 91 prime-target pairs were presented nine times in the lexical decision task during the learning phase (see also procedure below). Some of the prime-target pairs in the SEM-s, SEM-w and EPIS conditions were kept unchanged in the test phase of the experiment. The remaining word targets and all the word targets of the NEU condition were paired to new, intralist or extralist, primes. In Table 4.5 the design of Experiment 10 with the three experimental factors semantic, episodic and prime status is shown. Semantic status denotes whether a prime-target pair is semantically strongly related (+++), semantically weakly related (+) or unrelated (-). Episodic status denotes whether the prime-target pair was studied or not during the learning phase. Some of the prime-target pairs (episodic status = +++) were repeatedly presented in lexical decision and they were also presented for paired-associate learning and cued recall. There were also some prime-target pairs (episodic status = +) that were not presented in lexical decision but that were only presented for paired-associate learning and cued recall. The rest of the prime-target pairs (episodic status = -) were

Table 4.5.
The Eight Word Target Conditions of Experiment 10. These Conditions Vary Across Three Experimental Factors. See Text for Explanation.

Condition	Semantic status	Episodic status	Prime status	Trial 1-9	Trial 10
1	+++	+++	unchanged	A1-C1	A1-C1
2	+++	-	extralist	A3-C2	A2-C2
3	+	+++	unchanged	B3-C3	B3-C3
4	+	-	extralist	A5-C4	B4-C4
5	+	+	unchanged	B5-C5	B5-C5
6	+	-	extralist	A6-C6	B6-C6
7	-	+++	unchanged	A9-C7	A9-C7
8	-	-	intralist	A7-C8	A5-C8

Note. A and B = Prime; C = Target.

changed pairs. These were neither presented during lexical decision nor presented for paired-associate learning and cued recall. The last experimental factor, prime status, indicates whether a word target in the test phase is preceded by the same prime as in the learning phase (unchanged), preceded by a prime that was paired to another word target in the learning phase (intralist) or preceded by a prime that had not been presented earlier during the experiment (extralist). The combination of the three experimental factors led to eight experimental conditions of prime-target pairs in the experiment. As can be seen in Table 4.5, it is not possible to assess the effect of prime status, i.e. to investigate the performance of extralist versus intralist primes for changed, semantically related and unrelated, prime-target pairs. This is due to the fact that the design of Experiment 10 was optimized for the learning phase with its four word target and two nonword target conditions. It was not possible to construct more than 91 word triplets on basis of the consulted word association norms, because of the restriction that none of the words (two primes and one target) in a triple could occur in other triples. Therefore, the design of the test phase is not balanced as it was in Experiments 8 and 9. Nevertheless, the design can provide useful information in addition to the effects that might be found in the learning phase.

In Table 4.5 a C always refers to a target and the A and the B always refer to a prime. If the prime and the target have the same index then this means that they are semantically strongly related (e.g., A1-C1) or semantically weakly related (e.g., B3-C3), otherwise they are unrelated (e.g., A9-C7). Conditions 1 and 7 contain prime-target pairs that are respectively subsets of the SEM-s and EPIS conditions in the learning phase. All prime-target pairs of Condition 3 were presented as pairs in the SEM-w condition during the learning phase. Hence, the prime-target pairs of the Conditions 1, 3 and 7 are the learned associations (episodic status = +++) in the test phase. The learned associations only differ with respect to semantic status. Conditions 4, 5 and 6 contain targets that were presented in the NEU condition of the learning phase. In Condition 5 there are semantically weakly related prime-target pairs (semantic status = +) that were presented in the paired-associate task, but not in the lexical decision task during the learning phase (episodic status = +). Conditions 4 and 6 have word targets that were re-paired to extralist primes. Lastly, the Conditions 2 and 8 are the neutral conditions for Conditions 1 and 7 respectively. The neutral conditions of the test phase contain prime-target pairs that were not studied in the experiment (episodic status = -). In Condition 2 the targets are preceded by changed, extralist primes, and in Condition 8 they are preceded by changed, intralist primes. As noted, with the design of Experiment 10 it is not possible to contrast semantically related and unrelated prime-target pairs with respect to the difference in performance between extralist and intralist primes.

In Table 4.6 we have summarized how the stimulus materials of the master file in Experiment 10 were distributed to the several word and nonword target conditions in the learning and test phase of the experiment.

Table 4.6.
Overview of the Assignment of the Stimulus Materials From the Master File to the Word and Nonword Target Conditions in the Learning and Test Phase of Experiment 10.

Master file:	91 word triplets
Learning phase:	14 SEM-s
	14 SEM-w
	14 EPIS
	21 NEU (*blank* primes)
	20 word prime - nonword target combinations
	8 *blank* prime - nonword target combinations
Test phase:	7 SEM-s
	7 NEU-s
	14 SEM-w
	21 NEU-w
	7 EPIS
	7 NEU-u
Lexical decision:	20 word prime - nonword target combinations
	8 *blank* prime - nonword target combinations

Note. NEU-s = changed pairs that are semantically strongly related; NEU-w = changed pairs that are semantically weakly related; NEU-u = changed pairs that are semantically unrelated. The codes for the remaining word target conditions are the ones that were defined in the text: SEM-s, SEM-w, EPIS and NEU.

4.4.1.3. Procedure

The learning phase of the experiment involved nine presentations of 91 prime-target pairs in lexical decision. The nine presentations were given in three sessions, each session consisting of three presentation blocks. Each session was on a different day, so every subject had to come three times to the laboratory. The time interval between sessions was between 24 to 48 hours, so that the three sessions were always completed in one week. At the beginning of each session 42 practice trials were given for the purpose of getting familiarized with the lexical decision task at the first session and for the purpose of warm-up at the second and third session. All word targets were presented nine times (three presentations at each session) in a paired-associate task. In this task all word targets in the NEU condition were re-paired to a word prime and then presented for study. All word targets in the SEM-s, SEM-w and EPIS conditions were studied with the same prime as in the lexical decision task (for more details, see below). At the end of each session, after three presentations in the lexical decision and paired-associate task, a cued recall test was administered. After the learning phase and a short break, subjects began with the test phase. One group of subjects started with the lexical decision task and then continued with the perceptual identification task, another group of subjects performed the tasks in reversed order. Before the perceptual identification task, subjects first started with 10 practice trials in order to familiarize with the task. Next, the presentation time for the prime and target was determined with the estimation procedure as described in the method section of Experiment 8. The estimated presentation time was then used as presentation time for the prime and target in the ensuing perceptual identification task in the experiment proper.

Lexical decision and paired-associate learning. The procedure for the lexical decision task in Experiment 10 was equivalent to that of Experiments 8 and 9. All SOAs were equal to 140 ms. After a subject had made a response to a target feedback with respect to the accuracy and speed of the response was always given. In addition, after the feedback and given that the target was a word, the prime and target were again shown both in the middle of the computer screen for five seconds. These then formed the stimulus and response term in the paired-associate task. If the prime had been the *blank* prime, it was substituted by another word which would then form the stimulus term. The instruction given to the subjects was to look accurately at the stimulus and response term and to remember they had seen them together. Further, they were also told that their memory for the stimulus-response pairs would be tested later in the experiment. There were a total of 63 word targets preceded by a word or a *blank* prime in lexical decision. Consequently, there were 63 stimulus-response pairs in the paired-associate task, and 21 of the stimulus terms were words that replaced the *blank* prime. The combination of the lexical decision and paired-associate task was only performed during the learning phase of the experiment. In the lexical decision task during the test phase, always feedback with respect to speed and accuracy was given, after the subject had made a response, but a prime and target were never presented again for paired-associate learning.

Cued recall. At the end of each session a cued recall test was administered for the 63 stimulus-response pairs of the conditions SEM-s, SEM-w, EPIS and NEU. The stimulus term of a pair was displayed for seven seconds on the computer screen and subjects were instructed to write down the response term of the pair.

Perceptual identification. The procedure for the perceptual identification task in the test phase was equivalent to the procedure in Experiments 8 and 9. After the subject had made a response, the prime and target were shown again, but only for the purpose of feedback and not for the purpose of explicit learning.

4.4.1.4. Apparatus

The same apparatus as in experiment 8 and 9 was used for the lexical decision and perceptual identification task.

4.4.2. Results

4.4.2.1. Lexical decision

Learning phase: Reaction time data. Only reaction times of correct responses to word targets and reaction times longer than 150 ms and shorter than 900 ms were submitted for statistical analysis. For each subject, per word target condition mean reaction times were computed on each presentation and on these means the statistical analysis was performed. Because for each subject the stimulus material was randomly chosen from a master file, only subject-analyses could be performed (see Appendix A, page 126). In Figure 4.10 the reaction times for the word target conditions SEM-s, SEM-w, EPIS and NEU as a function of number of presentations in the learning phase are displayed. As can be seen by inspection of this figure, lexical decision times in all word target conditions decrease as a function of presentation number. For the NEU condition this means that the reaction times become faster as a result of repetition priming. It can also be seen that there is almost no difference between the conditions with semantically related primes, i.e. SEM-s and SEM-w. This was statistically tested by a four-way ANOVA with group (presentation order of lexical decision and perceptual identification in the test phase) as between-subjects factor, and prime type (SEM-s, SEM-w), session (three days) and presentation (three

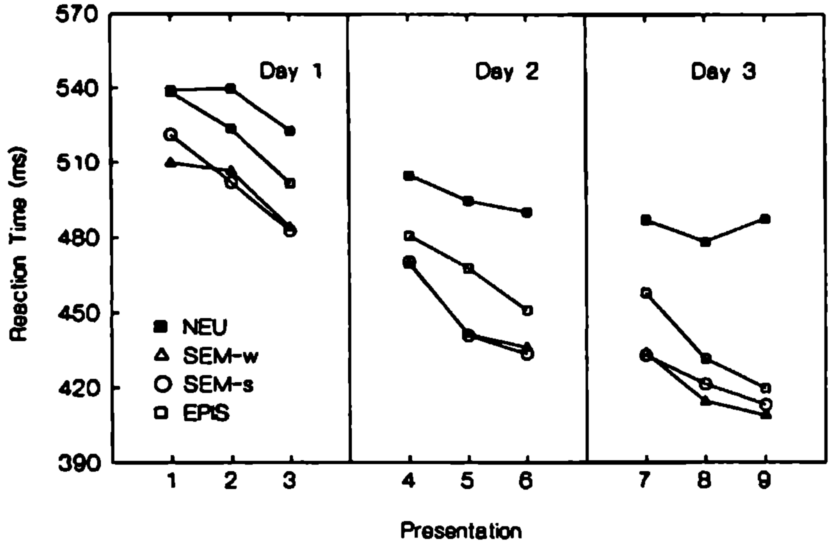

Figure 4.10. The learning phase of Experiment 10. Reaction times (in milliseconds) in the lexical decision task as a function of prime type (SEM-s, SEM-w, EPIS and NEU) and presentation number.

presentations within each session) as within-subjects factors. Only the main factors session ($F(2,50) = 82.37$, $p < .001$) and presentation ($F(2,50) = 32.54$, $p < .001$) were statistically significant. Because there is no difference between SEM-s and SEM-w, in all the following analyses we combined both conditions into one condition of semantically related primes, SEM. Further inspection of Figure 4.10 shows that there is a semantic priming effect on Presentation 1, as evidenced by faster lexical decision times for the SEM condition in relation to the NEU condition. Further, it can be seen that after Presentation 1, lexical decision times for the SEM and EPIS conditions decrease relatively faster than those for the NEU condition. This indicates a clear effect of episodic priming. Most interestingly however, is the interaction between the EPIS and the SEM condition on Day 3. Lexical decision times decrease relatively faster for the EPIS condition than those for the SEM condition. Also, the difference between the SEM and EPIS condition on Presentation 1 is approximately 23 ms, and this difference reduces to approximately 9 ms on Presentation 9. These data, for the first time, indicate an effect of semantic learning. A four-way ANOVA was performed with the between-subjects factor group and the within-

Table 4.7.
Error Percentages for the Four Word Target Conditions as a Function of Presentation Number During the Learning Phase of Experiment 10.

	Presentation								
Conditions	1	2	3	4	5	6	7	8	9
SEM-s	2.4	0.0	0.8	0.3	0.3	0.8	0.5	0.0	0.3
SEM-w	2.6	0.8	0.5	0.3	1.1	0.5	0.0	0.5	0.3
EPIS	1.9	1.3	0.3	0.5	0.5	0.0	0.5	0.8	0.5
NEU	1.4	0.5	1.8	2.1	1.6	1.4	1.8	1.2	1.6

subjects factors prime type (SEM, EPIS and NEU), session and presentation. All within-subjects factors, prime type, session and presentation, were statistically significant with respectively $F(2,50) = 128.58$, $p < .001$, $F(2,50) = 64.03$, $p < .001$ and $F(2,50) = 23.12$, $p < .001$. Of all the interactions, those of Prime type x Session ($F(4,100) = 16.83$, $p < .001$) and Prime type x Presentation ($F(4,100) = 8.97$, $p < .001$) were significant. Thus, these results indicate a reliable effect of episodic priming. Next, we restricted the ANOVA to the prime types of SEM and EPIS, and to Day 3, in order to test the semantic learning effect. This resulted in significant main effects of prime type ($F(1,25) = 26.87$, $p < .001$) and presentation ($F(2,50) = 31.45$, $p < .001$) and also in a significant interaction between both factors ($F(2,50) = 4.68$, $p < .015$).

Learning phase: error data. An error was scored, whenever a subject responded with 'nonword' when a 'word' response was required. In Table 4.7 the error percentages for SEM-s, SEM-w, EPIS and NEU in the lexical decision task are depicted as a function of presentation number. Most errors were made in the NEU condition. The error percentages in the SEM-w, SEM-s and EPIS conditions were approximately equal. This means that the reaction time data cannot be simply explained by a Speed Accuracy Trade-off function.

Table 4.8.
Results for the Eight Conditions in the Test Phase of Experiment 10. In the Two Right-Hand Columns Reaction Times (in Milliseconds) and Error Percentages (Between Parentheses) in the Lexical Decision Task (LD) and Proportions Correctly Identified Targets in the Perceptual Identification Task (PI) Are Shown.

	Experimental factors			Task	
Condition	Semantic status	Episodic status	Prime status	LD	PI
1	+++	+++	unchanged	401 (1.6)	.672
2	+++	-	extralist	451 (5.8)	.624
3	+	+++	unchanged	402 (1.1)	.653
4	+	-	extralist	456 (1.6)	.646
5	+	+	unchanged	415 (0.5)	.630
6	+	-	extralist	447 (2.1)	.587
7	-	+++	unchanged	417 (2.1)	.646
8	-	-	intralist	435 (2.6)	.513

Test phase. All analyses of the test phase data were carried out with the between-subjects factor group (presentation order of the lexical decision task in the test phase), but this factor never reached significance, neither as a main effect, nor in any interaction. In the second column at the right-hand side of Table 4.8 the lexical decision times of the conditions 1 through 8 are shown. Condition 3 contains prime-target pairs that were all presented as SEM-w pairs during the learning phase. The Conditions 4, 5 and 6 all contain changed prime-target pairs that are semantically weakly related, and have targets that were all presented in the NEU condition during the learning phase. As can be seen in Table 4.8, the performance in Condition 5 is better than in Conditions 4 and 6. This might be due to the fact that the prime-target pairs of Condition 5 were also presented in the paired-associate task during the learning phase. Conditions 4 and 6 both have targets that were paired to new, extralist primes that were not seen earlier in the learning phase of the experiment, not in the lexical decision task and not in the paired-associate task. It thus seems that for semantically weakly related prime-target pairs the paired-associate task had a facilitative effect on lexical decision times. This was confirmed by a one-way ANOVA with a significant contrast between on the one hand Condition 5 and on the other hand Conditions 4 and 6 ($F(2,50) = 14.08$, $p < .001$). Further, there was no difference between Condition 4 and 6 ($F < 1$). In the next analyses these conditions are combined. As can be seen further in Table 4.8, there is almost no difference between learned associations that are semantically strongly related (Condition 1) and those that are weakly related (Condition 3). In order to investigate the effect of episodic priming we contrasted the learned associations (Conditions 1, 3 and 7) with their respective baseline conditions. First, for the semantically strongly related prime-target pairs there is a large contrast between Condition 1 and Condition 2 ($F(1,25) = 24.32$, $p < .001$). Next, for the semantically weakly related prime-target pairs there is a significant contrast between Condition 3 and the combination of Conditions 4 and 6 ($F(1,25) = 72.61$, $p < .001$). This contrast is evidence of an episodic priming effect for SEM-w that is the combined result of learning in the lexical decision and the paired-associate task. In addition, there is also a significant contrast between Condition 3 and Condition 5 ($F(1,25) = 6.58$, $p < .018$). This means that the episodic priming effect is the result of paired-associate learning only. Finally, for the semantically unrelated pairs we contrasted Condition 7 and Condition 8, and this was also significant ($F(1,25) = 6.26$, $p < .02$).

4.4.2.2. Perceptual identification

Again, all analyses were carried out with the between-subjects factor group (presentation order of the perceptual identification task during the test phase). However, none of its main effects and none of its interactions with other factors were significant. In the first column at the right-hand side of Table 4.8 the proportions correctly identified targets for the Conditions 1 through 8 are depicted. It can be seen that there are differences in performance between the Conditions 4, 5 and 6, but these were not statistically significant ($F < 1$). This means that paired-associate learning had no effect on semantically weakly related prime-target pairs in perceptual identification (but it did have an effect on lexical decision times, see previous section). In the next analyses the Conditions 4, 5 and 6 were combined into one baseline Condition for Condition 3 (SEM-w). In order to investigate whether there was transfer of learning effects from the lexical decision to the perceptual identification task, we contrasted the studied prime-target pairs of the Conditions 1, 3 and 7 with their respective baseline conditions (2, 4, 5, 6 and 8). Most interestingly, the

Table 4.9.
Proportion Recalled Targets with the Prime Given as Cue, as a Function of Word Target Condition and Session Number in Experiment 10.

Conditions	Session Day 1	Day 2	Day 3
SEM-s	.97 (.05)	.99 (.02)	1.00 (.00)
SEM-w	.87 (.12)	.98 (.04)	.99 (.03)
EPIS	.72 (.25)	.91 (.14)	.98 (.08)
NEU	.91 (.11)	.97 (.05)	.99 (.02)

contrast between Conditions 7 (EPIS) and 8 was statistically significant with $F(1,25) = 4.84$, $p < .04$. The contrast between Conditions 1 (SEM-s) and 2 and the contrast between Condition 3 (SEM-w) and the combined Conditions 4, 5 and 6 were not statistically significant, with $F < 1$ and $F(1,25) = 1.08$, $p > .30$ respectively. These results indicate that only the episodic priming effect in the EPIS condition transferred from the lexical decision to the perceptual identification task. Another interesting aspect of Table 4.8 is that there is almost no difference in identification of targets between all the conditions with learned associations (Conditions 1, 3 and 7). The statistical analysis revealed nonsignificance ($F < 1$).

4.4.2.3. Cued recall

During the learning phase, at the end of each session, i.e. after three presentations of prime-target pairs in lexical decision and paired-associate learning, a cued recall test was administered. In Table 4.9 the results of this test for the conditions SEM-s, SEM-w, EPIS and NEU after each session are shown. As can be seen, and in accordance with the cued recall tests in previous experiments, targets with primes that are semantically strongly related are recalled best. In addition, recall in all conditions increases with day number. At Day 3 there is perfect recall for SEM-s and nearly perfect recall for the other conditions.

Because of this we restricted statistical analysis to Day 1 and 2. A two-way, within-subjects ANOVA revealed significant main effects of the word target condition ($F(3,78) = 18.07$, $p < .001$) and session ($F(1,26) = 36.96$, $p < .001$). The interaction was also significant ($F(3,78) = 17.58$, $p < .001$), indicating that from Day 1 to Day 2 the SEM-w, EPIS and NEU conditions approached perfect recall. Recall for the NEU condition is better than for the EPIS condition. This is due to the fact that the NEU condition contained seven word pairs that were semantically strongly related and seven that were semantically weakly related during paired-associate learning.

4.4.3. Discussion

As in previous experiments we again found reliable effects of episodic priming for learned associations, semantically related and unrelated. Repetition in lexical decision and paired-associate learning of these associations had a facilitative effect on reaction times, as was shown in the two phases of the experiment. During the learning phase the facilitation of the SEM and EPIS conditions in comparison to the NEU condition, constituted the evidence for episodic priming. During the test phase the same effect was demonstrated again, when it was shown that the lexical decision to word targets with unchanged primes was facilitated as compared to word targets with changed (intralist or extralist) primes. Further, it was also shown that paired-associate learning was a sufficient condition for episodic priming of semantically weakly related targets. Thus, in Experiment 10 the evidence for episodic priming was two-fold: With two types of neutral conditions we have measured the facilitation of the learned prime-target pairs. Also, the episodic priming of lexical decisions in the test phase of Experiment 10 is a replication of the episodic priming that we found in the test phase of Experiment 8. In that experiment learning instructions to the subjects were the same as in this experiment, although there were fewer learning trials. Because of limitations to our stimulus material we could not test the experimental factor of prime status in Experiment 10. In Experiment 8 we found that targets preceded by intralist primes had faster lexical decision times than targets preceded by extralist primes. This was referred to as the list-wide priming effect. In the test phase of Experiment 10 the facilitation of the SEM condition was measured in comparison to targets preceded by semantically related, extralist primes. The effect was quite substantial, approximately 50 ms. It is likely that had the SEM condition been compared to targets preceded by semantically related, intralist primes, the facilitation would have been reduced. The facilitation of the EPIS condition was measured in relation to a neutral condition with intralist primes, and was significant. However, if the EPIS condition had been compared to a neutral condition with extralist primes, it is likely that the facilitation would have been larger.

In Experiment 2 there was a possible confounding to the episodic priming found with the learned associations. In that experiment the targets of the neutral prime condition were not seen and studied during the paired-associate task. Therefore it was concluded that the word target conditions were not matched with respect to the magnitude of repetition priming and any firm conclusions about the effect of episodically learned associations were not possible. In the present experiment, however, each *blank* prime paired to a word target in the neutral condition was replaced by a word prime, and both word prime and word target were presented during paired-associate learning.

The most important result of Experiment 10 is that for the first time we have found an indication that the newly learned associations were added to semantic memory. During the learning phase of the experiment the difference in lexical decision times between the EPIS and the SEM condition decreased to approximately 9 ms on the last presentation of the third day. At the beginning of the learning phase, on the first presentation, this difference was approximately 23 ms. Additionally, when the statistical analysis was restricted to the third day of the learning phase it was found that there was a significant interaction between the EPIS and the SEM condition.

The results of the test phase constituted additional evidence that the newly learned associations were added to semantic memory. The facilitative priming of lexical decisions with the newly learned associations transferred to the perceptual identification task. This suggests that the newly learned associations became semantic, because the newly learned information could be activated independent of the specific task. The facilitation of the lexical decisions of the learned prime-target pairs in the SEM-s and the SEM-w conditions did not transfer to the perceptual identification task. This indicates that the learned associations between primes and targets that are semantically associated were coded in episodic memory and that the semantic associations were not strengthened in semantic memory. Otherwise, if the semantic associations had been strengthened then we should also have observed that the facilitative priming effects of these associations showed transfer to the perceptual identification task.

A defining characteristic of semantic memory is that information that has been incorporated in it is context-independent (see the introduction of this thesis). For the present experiment the incorporated information that had an effect in one context, i.e. the lexical decision task, had similar effects in another context, i.e. the perceptual identification task. Note that in our arguments we assume that the lexical decision task and the perceptual identification task constitute different contexts. The results of the test phase are supported by experiments of Potts, St.John and Kirson (1989; but see also Potts & Peterson, 1985). They manipulated the extent to which newly learned information was incorporated into a base of known facts by telling subjects whether they were learning real or artificial facts in a story context during the study phase. In a consecutive test phase subjects were required to retrieve the newly learned information by answering questions in two contexts: A context similar (*story context*) or dissimilar (*nonstory context*) to the context during the study phase. Potts et al. found that subjects who believed they were learning artificial facts showed large differences in reaction times between both test contexts, with longer reaction times in the dissimilar context. In contrast, subjects who believed they were learning real facts showed only small differences in reaction times, with answering questions in the dissimilar nearly as fast as those in the similar context. Thus, in their experiments Potts et al. demonstrated context-independency of newly learned information.

In Experiment 8, facilitative priming of newly learned associations in the lexical decision task did not transfer to to the perceptual identification task. This result does not contradict the present results, because in Experiment 8 there were fewer study trials in the learning phase, which might have been insufficient for semantic learning.

We admit that the evidence for semantic learning is still weak, but we think that our approach is a good starting point for further research. In new experiments it will have to be investigated whether the effects can be replicated and whether paired-associate learning with even more trials is necessary to observe stronger effects of semantic learning.

In Experiment 10 we did not find evidence for the associative strength effect. In fact, there was no difference in performance between the word targets with the semantically strongly associated (SEM-s) and semantically weakly associated (SEM-w) primes. Although both conditions differed substantially with respect to free association norms, with mean association frequencies of 48.2 and 2.9 for SEM-s and SEM-w respectively, it appears that the prime-target pairs in both conditions were of equal strength. This may be due to the method that was used in the studies for determining association frequency (De Groot, 1980; Lauteslager, Schaap & Schievels, 1986; Van Loon-Vervoorn & Van Bekkum, 1991). In these studies subjects were instructed to say or to write down the first word that came to mind in response to a stimulus word. This method may be reliable for finding strong associations, but less reliable in finding weak associations. If subjects would have the opportunity to respond with, for example, the first five words that come to mind, it might turn out that our 'weak' associates were in fact reasonably strong.

4.5. General discussion

Two main conclusions can be drawn with respect to the experiments described in this chapter. First, the episodic priming effects observed in the experiments described in the Chapters 2 and 3 were replicated. In Experiment 8, the episodic priming effects in lexical decision for both the EPIS and the SEM condition were a replication of the episodic priming effects in perceptual identification for the same conditions in Experiment 6. Although different semantic memory tasks were used, the designs in both experiments were quite similar. Prime-target pairs were repeatedly presented in a semantic memory task and as paired associates for explicit study during a learning phase, and in a following test phase the studied prime-target pairs were compared to changed prime-target pairs. The results of Experiment 9 showed that presenting word pairs for paired-associate learning is a sufficient condition for episodic priming in perceptual identification for both the EPIS and the SEM condition. With respect to episodic priming, Experiment 10 was a replication of Experiment 2, because during the learning phase the EPIS and SEM conditions were facilitated more in lexical decision than the NEU condition. In both experiments the NEU condition consisted of the neutral primes *blank*. The surplus value of the experiments described in this chapter in comparison to previous experiments, is that it has been demonstrated that episodic priming is dependent on the overlap between study and test context. In Experiments 8 and 9, there was only episodic priming if the task environments in the test and learning phase were similar.

The second main conclusion that can be drawn with respect to the results described in this chapter, is that there was evidence for semantic learning. In Experiment 10 there was an interaction between the EPIS and the SEM condition during the learning phase, with the lexical decision times of the EPIS condition being facilitated more than those of the SEM condition. Also, the facilitative effects for the EPIS condition transferred from the lexical decision task to the perceptual identification task. Thus, there was facilitation for the EPIS condition even when the overlap in study and test context decreased. The facilitative effects for the SEM condition did not transfer from the lexical decision task to the perceptual identification task. This probably indicated that the preexperimental associations were not strengthened in semantic memory, but that only context-dependent, episodic codes were formed for these associations.

The experiments in this chapter have demonstrated that the presence or absence transfer of priming effects provided clues with respect to the type of learning effect, i.e. episodic or semantic.

CHAPTER 5

GENERAL DISCUSSION: IMPLICATIONS AND PERSPECTIVES

The central issue of this thesis was under which conditions are newly learned associations added to semantic memory. The basic assumption was that episodic learning experiences are a necessary condition for the formation of new semantic associations. Addition to semantic memory was assumed to be accomplished if it could be shown that the priming of newly learned associations was functionally equal to the priming of preexperimentally related word pairs. We used a paradigm in which semantically related (SEM condition) and semantically unrelated (EPIS condition) prime-target pairs were repeatedly presented for lexical decision or perceptual identification, with or without explicitly instructing subjects to study the pairs. This paradigm was a kind of 'learning monitor', that enabled us to study the effects of two learning components, an episodic and a semantic one.

Semantic learning

Both the learning and the test phase of Experiment 10 provided evidence for the formation of new semantic associations. During the third day of the learning phase the lexical decision times of the new associations in the EPIS condition were facilitated more in comparison to those of the preexperimental associations in the SEM condition. The observed interaction was not the result of any floor effect for the SEM condition, because performance in this condition continued to improve with repeated presentations on the last day of the learning phase.

The indication of a semantic learning component during the learning phase of the experiment was confirmed by the results of the test phase. The priming effects for the newly learned associations in the EPIS condition transferred from the lexical decision to the perceptual identification task. This indicates that these associations had become at least partially context-independent, which is a defining characteristic of semantic memory. In contrast, the priming effects for the associations in the SEM condition did not transfer to the perceptual identification task. The most likely explanation for this is that during the learning phase a context-dependent episodic code for each preexperimental association was formed (see also below). If the preexperimental associations had been strengthened, which is a quantitative change only, then it is hard to conceive how this should explain that no transfer effect was found for the SEM condition.

One aspect that remains unclear is why the procedure for the paired-associate task in Experiment 10 was sufficient for semantic learning, and not the procedure that we used for the anticipation task in Experiment 2. A possibility is that the former procedure may have stimulated the subjects to process the word pairs with respect to their meaning, which may have not been the case in Experiment 2. More attention will be given to this aspect in future research.

Dagenbach, Horst and Carr (1990) also reported evidence for the formation of new semantic associations. In their Experiment 3, the facilitation of the episodically related prime-target pairs relative to the episodically unrelated prime-target pairs (their Conditions 1 and 2 respectively), was equivalent to the facilitation of the semantically and episodically related prime-target pairs relative to the semantically and episodically unrelated prime-target pairs (their Conditions 4 and 6 respectively). However, the comparison of both facilitations is not justified, because the semantically related prime-target pairs of Condition 4 received less study than the semantically unrelated prime-target pairs of Condition 1. As a consequence, the pairs did not match with respect to amount of episodic priming[1], which excludes any firm conclusions about semantic learning.

A conclusion that can be drawn from our research is that the paradigm of Salasoo, Shiffrin and Feustel (1985) used for studying the formation of new word codes, is also appropriate for studying the formation of new codes representing the semantic relationship between word nodes. Moreover, as we have shown, a measure of context-independent performance offers an interesting possibility as an additional check on the validity of the results. More research is needed to confirm whether our paradigm is a good starting point for the investigation of semantic learning, more specifically the learning of new semantic associations.

---

[1] Of course, the pairs also did not match with respect to repetition priming, but that does not cause a problem, because this match is only important with respect to the within-contrast comparisons (Condition 1 vs. 2 and Condition 4 vs. 6).

As was suggested by Durgunoglu and Neely (1987), episodic priming is an effect that depends on a complex configuration of variables, at least in relation to the lexical decision task. With the results of the experiments reported in this thesis we can clearly delineate the conditions that are sufficient for the episodic priming of studied associations, semantically related (SEM) and unrelated (EPIS), not only in the lexical decision task, but also in the perceptual identification task. As it turns out, the findings are quite similar for both tasks.

In Experiment 1 it was found that repeating prime-target pairs in the lexical decision task, without explicit instruction to study, was a sufficient condition for episodic priming in the EPIS condition. The facilitation observed in this condition was measured against a baseline condition (NEU) which consisted of repetitions of targets that were always preceded by the neutral prime *blank*. Den Heyer (1986) who investigated similar prime-target pairs (SEM, EPIS and NEU) under the same conditions as in our Experiment 1, did not find any evidence for episodic priming in the EPIS condition. But this is probably due to the fact that in his experiment prime-target pairs were only presented five times, while in our experiment they were presented 16 times. The results of Experiment 1 run counter to what Durgunoglu and Neely (1987) have claimed to be necessary conditions for episodic priming in the EPIS condition with short SOAs in a lexical decision task, namely that a) all word targets are studied and all nonword targets are nonstudied, and b) no semantically related prime-target pairs are presented during lexical decision. Repeating semantically unrelated prime-target pairs without explicit instruction to study is also a sufficient condition for episodic priming of these pairs in the perceptual identification task. In Experiment 6 the prime-target pairs of the EPIS condition showed facilitation in comparison to a changed pairs condition during the test phase of that experiment. However, in Experiment 7 no episodic priming was found when the studied prime-target pairs were compared to a changed pairs condition during the learning phase of the experiment.

In the lexical decision task, the sufficient condition for episodic priming in the SEM condition was repeating prime-target pairs with explicit instruction to study the pairs. In Experiments 2 and 10 the episodic priming was observed during the learning phase and in relation to a baseline condition with the neutral prime *blank*. In Experiment 8 the effect was observed in relation to the changed pairs condition during the test phase of that experiment. And it was again observed in the test phase of Experiment 10 in comparison to a changed pairs condition with extralist primes only.

With respect to the perceptual identification task, it was sufficient to repeat the semantically related prime-target pairs, without explicit instruction to study, in order to observe episodic priming in the SEM condition (Experiment 6). The effect was measured relative to a changed pairs condition during the test phase of the experiment.

In all experiments in which the subjects were instructed to study the prime-target pairs, i.e. with the addition of a paired-associate task, evidence was found for episodic priming in the EPIS and SEM conditions. The only exceptions were those experiments, where during the learning phase the baseline condition consisted of changed pairs (Experiments 5 and 7)[1]. Currently, we have no explanation for the difference in results between the experiments for which we used changed pairs as a baseline condition and experiments for which we used targets paired to the neutral prime *blank* as a baseline condition during the learning phase. A possibility is that the prime-target pairs in the changed pairs condition did not constitute a 'true' baseline condition, but instead were facilitated by a process that we previously referred to as the list-wide priming effect (Smith, MacLeod, Bain & Hoppe, 1989), thereby leading to the failure to observe any learning effects in the SEM and EPIS conditions. Although it was prevented that associative links could be formed in the changed pairs condition, it is possible that a prime in this condition constituted a context cue that facilitated the processing of a target it was paired to. However, this explanation is problematic. Under the assumption that the same process is operative in the SEM and EPIS conditions, one would have to explain why there should be more list-wide priming in the changed pairs condition than in the SEM and EPIS conditions. In future research this issue will be given more attention.

Tulving (1983) has stated that the retrieval of information in episodic memory is slow and deliberate. Clearly, our results concerning episodic priming suggest that the information in episodic memory can also be retrieved fast and automatically. Below we will have more to say about the implications of episodic priming.

In Table 5.1 a summary is given of all the experiments described in this chapter. In this table the results with respect to episodic priming (in the SEM, EPIS, or both conditions), but also semantic learning are shown in relation to a number of conditions that were

---

[1] Experiment 3 is also an exception, although in this experiment no paired-associate task was administered, but only a sentence generation task.

manipulated in the experiments. These conditions are:

1. Memory tasks. In all experiments at least one semantic memory task was used, viz. lexical decision (LD) or perceptual identification (PI). Most experiments also had a cued recall task (CR).

2. Learning conditions. All experiments consisted of a learning phase with repeated presentations of word pairs. The experiments differed with respect to whether there was an explicit instruction to study the word pairs (intentional learning) or not (incidental learning). Further, in Experiment 3 subjects were instructed to generate sentences and in the EPIS conditions the primes consisted of new vocabulary words (NVW).

3. Number of repetitions of word pairs in the learning phase. In Table 5.1 *a* x *b* repetitions denotes that there were *b* presentations on each of *a* days.

4. NEU condition. The neutral conditions consisted of *blank* primes (BLa) or *changed pairs* (CHa).

5. Semantic priming. It is indicated in which semantic memory task a semantic priming effect was found.

Experiments 1 through 5 only consisted of a learning phase. Experiments 6 through 10 also consisted of a test phase. For these experiments results are separately shown for both phases (L = Learning phase, T = Test phase).

Table 5.1.

Overview of All the Experiments Described in This Thesis, With an Indication of Episodic and Semantic Learning Effects in Relation to Memory Tasks, Learning Conditions, Number of Repetitions and Type of NEU Condition. Shown is Also in Which Memory Tasks Semantic Priming Was Found.[1]

Exp.	Memory tasks	Learning condition	Numb. of rep.	NEU	Episodic learning	Semantic learning	Semantic priming
1	LD	Incidental learning	4 x 4	BLa	EPIS	-	LD
2	LD,CR	Intentional learning	4 x 4	BLa	EPIS,SEM	-	LD
3	LD	Sentence generation, NVW	2 x 6	CHa	-	-	LD
4	PI	Incidental learning	1 x 5	CHa	-	-	PI
5	PI,CR	Intentional learning	1 x 5	CHa	-	-	PI
6	L:PI,CR T:PI	Incidental learning	1 x 4	T:CHa	T: EPIS,SEM	-	L:PI T:PI
7	L:PI,CR T:PI	Intentional learning	1 x 4	L:CHa T:CHa	T: EPIS,SEM	-	L:PI T:PI
8	L:LD,CR T:LD,PI	Intentional learning	1 x 4	T:CHa	T,LD: EPIS,SEM	-	L:LD T:LD,PI
9	L:PA T:LD,PI	Intentional learning	1 x 4	T:CHa	T,PI: EPIS,SEM	-	T:LD,PI
10	L:LD,CR T:LD,PI	Intentional learning	3 x 3	L:BLa T:CHa	L,LD:SEM T,LD:SEM	L,T,LD, PI:EPIS	L:LD T:LD,PI

Note. Exp. = Experiment; Numb. of rep. = Number of repetitions; L = Learning phase; T = Test phase; LD = Lexical Decision task; PI = Perceptual Identification task; PA = Paired-Associate task; CR = Cued Recall task; NVW = New Vocabulary Words; BLa = NEU condition with *Blank* primes; CHa = NEU condition with Changed pairs.

[1] With special thanks to Diane Pecher for her assistance in the construction of this table.

In Chapter 1 of this thesis the role of context as a feature that distinguishes episodic and semantic memory was discussed. In the Experiments 8, 9 and 10 the role of context was investigated by testing learning effects in two contexts: One context similar, and one context different to the context during the learning phase. We manipulated context as the specific task in which prime-target pairs were presented. This included not only the task procedures (lexical decision or perceptual identification), but also the apparatus (tachistoscope or personal computer), type font (small or large letters) and color of the letters (green or orange). We found episodic priming in the EPIS and SEM conditions when the task procedures during study and test phase were similar, but not when they differed (Experiment 8). In addition, episodic priming in the EPIS and SEM conditions was also found when the tasks in the learning and test phase where similar with respect to apparatus, type font and color of letters, but not when they differed with respect to these features (Experiment 9).

It was already noted that in Experiment 10 transfer of facilitation from the lexical decision task (study and test context similar) to the perceptual identification task (study and test context different) was observed for the prime-target pairs in the EPIS condition. This context-independent effect suggested that the newly learned associations were added to semantic memory.

The episodic priming effect that we observed for the SEM condition in Experiments 8, 9 and 10, indicates that a context-dependent, episodic code for the co-occurrence of two semantically related words was formed. It would be interesting to investigate further what learning conditions are sufficient for the strengthening of already existing links in semantic memory, and to find out whether the priming effects that are the result of such learning are indeed context-independent.

Another interesting point would be to study the effects of manipulating context during the learning phase. In Chapter 1 we referred to a study by Watkins and Kerkar (1985), that provided evidence that information that is presented in different contexts during learning, leads to 'generic memory'. One way to study the effect of context during the learning of new associations would be to present prime-target pairs in combination with a third word. We could then compare the performance of prime-target pairs that were studied with the same word on each presentation (context constant), with the performance of prime target-pairs that were studied with a new word on each presentation (context varied). We predict larger semantic learning effects would be found in a condition with context varied than in one with context constant (see also Haarmann & Mesman, 1994).

Two interacting memory components

Although it was not the main question in this thesis whether episodic and semantic memory are separate systems, the results of our experiments provide evidence that they are not, according to the method of transfer (Chapter 1). It was found that episodic information, i.e. episodic associations studied for later recall, had an effect in two semantic memory tasks, lexical decision and perceptual identification.

Transfer of information is best accounted for if the strict assumption of independence of memory systems (Tulving 1972, 1983; Tulving & Schacter, 1990) is abandoned, and if it is assumed instead that both memories are interactive components in one memory system. In Chapter 1 we offered a framework (see Figure 1.1), based on the study by Salasoo, Shiffrin and Feustel (1985), that showed how the interaction between the two memory components might be conceived. The assumptions underlying this framework are that first, learning experiences are the basis for the storage of information in semantic memory (see also Wolters, 1984; Carr, Dagenbach, VanWieren, Radvansky, Alejano & Brown, in press). Next, each presentation of a prime-target pair leads to the storage of an episode together with contextual information. Then, through some consolidation process on the episodes stored, a semantic representation emerges that is context-independent. Whether semantic knowledge arises from consolidation and is stored independently of episodes, or whether semantic knowledge is 'computed' from episodes (Hintzman, 1986), and is not stored independently, is an issue that is still open to debate (Carr, Dagenbach, VanWieren, Radvansky, Alejano & Brown, in press).

Tulving, Hayman and Macdonald (1991) have a different point of view. They found that a severely amnesic patient with no functional episodic memory was able to learn new semantic information. However, it remains unclear from what type of learning experiences this patient could profit, and whether this patient had no episodic memory at all, or suffered from an inability to retrieve information from episodic memory.

The research described in this thesis is still in an inductive phase. We have sketched a framework that encompasses the assumptions concerning the learning of new semantic associations. This framework is only a theory stated in global terms. A likely candidate theory for describing the results of our paradigm formally, is the Compound Cue theory developed by Ratcliff & McKoon (1988) that is based on the Search of Associative Memory theory (Raaijmakers & Shiffrin, 1981; Shiffrin & Raaijmakers, 1992). The theory assumes that a prime and target, together with contextual information, are combined into a compound cue that is used to access information in long term memory. If the prime and target are associated then the match with memory is better than if they are not associated. A greater match facilitates the response to the target. Ratcliff and McKoon have demonstrated how the compound cue mechanism may be implemented in order to describe priming phenomena in lexical decision tasks. They also showed that the compound cue mechanism provides a better account of priming phenomena than spreading activation models.

In the current stage of our research it is too early to give a complete account in terms of the Compound Cue theory, because more experiments are necessary to validate the underlying assumptions of the global theory.

Semantic versus associative priming

One issue that has been addressed in the priming literature is whether the (automatic) semantic priming effect in lexical decision can also be observed with prime-target pairs that are semantically, but not associatively related (Fischler, 1977; Lupker, 1984; Seidenberg, Waters, Sanders & Langer, 1984; Hines, Czerwinski, Sawyer & Dwyer, 1986; Hodgson, 1991; Shelton & Martin, 1992). Given the assumption that words or concepts are nodes that are linked in a semantic network and activation spreads from one node to related nodes (Collins & Loftus, 1975; Anderson, 1983), it is predicted that the automatic priming effect is also observed with semantically related, but unassociated word pairs. As noted rightly by Shelton and Martin (1992), the findings concerning automatic priming observed with semantically related, unassociated pairs have been equivocal, due to problems with the statistics reported (see also Appendix A, page 126), but also because some priming effects might have been the result of strategic, instead of automatic processes. In their Experiments 1 and 2, Shelton and Martin provided evidence that the semantic priming in a single-presentation procedure[1] in the lexical decision task was automatic. In addition, they showed in their Experiments 3 and 4 that the automatic

[1] In this procedure a lexical decision is required for every word that is presented. Consequently, SOAs include the response duration for the prime. In Shelton and Martin's Experiment 3 the average duration of an SOA between prime and target was 1,025 ms.

automatic. In addition, they showed in their Experiments 3 and 4 that the automatic semantic priming in the single-presentation procedure is only found for associatively related prime-target pairs, but not for the semantically related, unassociated prime-target pairs. These findings led Shelton and Martin to the conclusion that in lexical decision the basis for automatic semantic priming is probably an effect in an orthograpic or phonological lexical network, because associations are the result of the frequent co-occurrence of two words[1] that were read or heard together. In their view, lexical decision does not constitute a useful task for studying the automatic retrieval of semantic information. This of course offers a challenge to our paradigm, where repetition of prime-target pairs in a lexical decision task with short SOAs formed the basis for investigating semantic learning.

First, with respect to strategic components, it is unlikely that these were operative in our experiments. Many of the effects that we found in lexical decision were also found in perceptual identification. Particulary in the latter task we checked whether strategic components were active. First, target names have to be 'generated' in perceptual identification, and therefore strategic effects that may be related to a decision task[2] are not likely. In addition, in none of our experiments it was found that the changed pair condition with intralist primes led to interference and thus to worse performance in comparison to the changed pairs condition with extralist primes. In the lexical decision task we found differences between the intralist and extralist conditions, but contrary to what would be expected with a strategic component, targets with intralist primes were facilitated relative to targets with extralist primes. This was probably an indication of the so-called list-wide priming effect.

With respect to the other point raised by Shelton and Martin, namely the co-occurrence

---

[1] Fischler (1977) refers to the frequent co-occurence of words as an 'accident of contiguity'.

[2] Postlexical checking is a strategic process that has been suggested to be operative in many lexical decision tasks (e.g., De Groot, Thomassen & Hudson, 1982; De Groot, 1983; Shelton & Martin, 1992). It is assumed that after a prime and target have been identified, it is checked whether there is a semantic relationship. If the target is a word, then a semantic relationship between prime and target leads to a fast response, because an affirmative check ('yes') is congruent with a 'word' response to the target. Refutation of a semantic relationship between prime and target ('no') is congruent with a 'nonword' response to the target. Switching over to a 'word' response then leads to a slowing down of the lexical decision time.

of words, we assume that associative learning constitutes an important factor for the storage of information in semantic memory, which is also a point of view held by other theorists. For instance, in the spreading activation theories of Collins and Loftus (1975) and Anderson (1983) it is assumed that the strength of a relationship between two nodes in the semantic network is determined by how often those nodes were processed together. However, the theories are silent about what constitutes sufficient or necessary conditions for the formation of a semantic link between nodes, and this has been the main topic of this thesis. Further, the mere co-occurrence of words, that in the view of Shelton and Martin would lead to representations in a phonological or orthographic lexical system, would in our view lead to representations in episodic memory that are context-dependent. The fact that Shelton and Martin did not find automatic priming with semantically related, unassociated word pairs, and given the fact that other studies which did find an effect are problematic, is in fact evidence that there is not an exclusively semantic network which is independent of a more association-based semantic memory.

APPENDIX A

STATISTICAL ANALYSIS

The use of the correct statistics in psycholinguistic studies or studies in the area of semantic memory has been problematic (Clark, 1973). The purpose of this Appendix is to give a justification of the statistics that we used in the experiments reported in this thesis. We want to show that if stimulus material is matched in experimental conditions (Experiments 1 through 4) or if for each subject a random selection is made from a master file containing the stimulus material (Experiments 5 through 10) then it is best to employ a subject-analysis (F_1).

A further goal of this Appendix is to discuss some of the relevant issues that have been raised after the critique of Clark (1973), and before him Coleman (1964), concerning the statistical analysis of language materials in the abovementioned areas. Clark's main critique was that, although researchers intended to generalize their findings beyond the specific language materials they used in their studies, they failed to provide the correct statistics to justify their generalizations. Selecting items randomly or pseudorandomly always leads to error variance that must be accounted for. If not, then there is the possibility that the error variance is confounded with the treatment effect. This is a problem whenever a conventional F test with items treated as a fixed effect is carried out. A solution to the problem is to treat both subjects and items as random effects, not in separate analyses, but in the same analysis.

Clark's 1973 article was complex, and in our view it is useful to reconsider and restate some of the issues in relation to our own research, but also in relation to the research of other investigators. In doing a statistical analysis we think that one should be aware of Clark's arguments, but should also know that these arguments are not mandatory. We illustrate our arguments with some case studies.

A.1. The language-as-fixed-effect fallacy

Repeated measurement designs are very popular in experimental psychology, because the costs are lower than for completely randomized designs. There is also a methodological advantage, because with repeated measurements the subjects will serve as their own controls. Assuming that an investigator is interested in an experimental treatment factor, the usual statistical analysis of the treatment effect involves computing an F ratio with the mean squares of the treatment variable in the numerator, and the mean squares of the Treatment x Subjects interaction in the denominator of the F ratio (Winer, 1971; Kirk, 1982). This type of analysis is a subject-analysis and the computed F value is referred to as F_1. In the subject-analysis the subjects are considered as the experimental units (Kirk, 1982). The datapoint of each subject in each cell of the design is computed by collapsing over items. If the resulting F value is significant, then the investigator will conclude that there is a real difference between treatments given the variance due to the selected sample of subjects (and of course the remaining, unexplained error variance) in the experiment. In a subject-analysis it is always assumed that the subject-factor is the only factor that constitutes a random effect.

Table A.1.
Expected Mean Squares of Repeated Measurements ANOVA With One Random Effect (Subjects) and One Fixed Effect (Treatment)[1]*: Subject-Analysis* (F_1).

Source of variation	Label	Df	Expected mean squares
Treatment	A	p-1	$\sigma_e^2+\sigma_{AC}^2+n\sigma_A^2$
Subjects	C	n-1	$\sigma_e^2+p\sigma_C^2$
Treatment x Subjects	AC	(p-1)(n-1)	$\sigma_e^2+\sigma_{AC}^2$

Note. Df = Degrees of freedom; p = number of levels of the treatment variable; n = number of subjects.

In Table A-1 the expected mean squares of a typical subject-analysis are shown. Because the subject factor is the only factor that is random, this implies that the investigator does not want to restrict the treatment effect to the sample of subjects selected, but wants to generalise the effect to a broader class of subjects.

The situation can be reversed by considering the items as the experimental units. A

[1] If the treatment factor is fixed then the proper expected mean square component is not $n\sigma_A^2$, but in fact $n\Sigma A^2/(p\text{-}1)$ (Kirk, 1982, p. 249).

datapoint for an item is obtained by collapsing over subjects. The statistical model that is used in analysing the resulting data is depicted in Table A-2. This model is a Split-Plot Factorial design with one grouping factor (Kirk, 1982). The assumption in this model is that items constitute a random effect, and the treatment variable is considered fixed. This is an example of an item-analysis.

Table A.2.
Expected Mean Squares in a Split-Plot Factorial Design With One Random Effect (Items) and One Fixed Effect (Treatment): Item-Analysis (F_2).

Source of variation	Label	Df	Expected mean squares
Treatment	A	p-1	$\sigma_e^2+\sigma_{B(A)}^2+n\sigma_A^2$
Items (within Treatment)	B(A)	$p(n$-1)	$\sigma_e^2+\sigma_{B(A)}^2$

Note. Df = Degrees of freedom; p = number of levels of the treatment variable; n = number of items.

The F value, which is referred to as F_2, is computed by dividing the mean squares of the treatment variable by the mean squares of the item (within treatment) variable. If the F_2 is significant then it is concluded that the treatment effect is real given the sample fluctuation of the chosen items. Additionally, the investigator concludes that the significant treatment effect is not restricted to the sample of chosen items, but can be generalized to a broader class of items. This is what investigators want: Not only generalize their findings beyond the sample of chosen subjects, but also beyond the sample of items chosen[1]. Otherwise their findings are too restrictive and of no theoretical importance.

In the sixties and seventies, investigators have mainly performed subject-analyses, and have therefore committed what Clark (1973) called the language-as-fixed-effect fallacy. The danger of this fallacy is that it can lead to Type I errors. A Type I error means that it is (wrongly) concluded that there is a treatment effect (accepting the alternative hypothesis), although in reality there is no such effect (the null hypothesis is true). The

[1] Of course, there are exceptions to this rule, because generalization is not always at stake. Examples of this are single case studies (see Clark, 1973).

error can be avoided by doing the correct statistics, i.e. by considering both subjects and items as random effects.

Having a treatment variable that is fixed (treatment) and two variables that are random (subjects and items), the statistical design changes to a more complex design. As an illustration, suppose that we wanted to investigate whether for one presentation there is a difference in lexical decision times between the targets of the SEM condition and the targets of the EPIS condition. We would select prime-target pairs for each condition, balance both conditions on relevant factors such as word frequency and length, and present all the stimuli to a sample of subjects for lexical decision. The statistical design to analyze the resulting reaction times would be a Mixed Hierarchical design (Winer, 1971) or a Split-Plot Factorial *pq* design[1] (Kirk, 1982, p. 489-502) with one fixed (prime-target condition) and two random effects (subjects and words).

Table A.3.
Expected Mean Squares of Repeated Measurements ANOVA With One Fixed Effect (Treatment) and Two Random Effects (Subjects and Words): Quasi F Analysis.

Source of variation	Label	Df	Expected mean squares
Treatment	A	p-1	$\sigma_e^2 + \sigma_{B(A)C}^2 + n\sigma_{AC}^2 + q\sigma_{B(A)}^2 + nq\sigma_A^2$
Words (within Treatment)	B(A)	$p(n$-1)	$\sigma_e^2 + \sigma_{B(A)C}^2 + q\sigma_{B(A)}^2$
Subjects	C	q-1	$\sigma_e^2 + \sigma_{B(A)C}^2 + np\sigma_C^2$
Treatment x Subjects	AC	(p-1)(q-1)	$\sigma_e^2 + \sigma_{B(A)C}^2 + n\sigma_{AC}^2$
Words x Subjects	B(A)C	$p(n$-1)(q-1)	$\sigma_e^2 + \sigma_{B(A)C}^2$

Note. Df = Degrees of freedom; p = number of levels of the treatment variable; q = number of subjects; n = number of items.

In Table A-3 the resulting ANOVA table with the expected mean squares is shown for these designs. If the investigator performs a subject-analysis as usual, with the Treatment x

[1] Kirk (1982) describes the Randomized Block Hierarchical *pq(A)* design that can also be applied in this situation and which is similar to the Split-Plot Factorial *pq* design. The difference between the two models is whether subjects or items are regarded as the experimental units.

Subjects interaction in the denominator of the F ratio, then there is no certainty whether a significant F value is due to a real treatment effect. The significant F value can be the result of the words within treatment effect, with $\sigma_{B(A)}^2 > 0$, where at the same time the variance due to the treatment effect, σ_A^2, is equal to zero. This is a real possibility because in any experiment it can be assumed that the variance due to items is greater than zero, even if the items are carefully selected and balanced as to word frequency and length. Thus, if the subject-analysis is performed then the $\sigma_{B(A)}^2$-component will inflate the F value with a resulting Type I error. The point is that when items are considered fixed, as is assumed in the subject-analysis (see Table A-1), then the $\sigma_{B(A)}^2$-component is unrightly deleted from the statistical model. A significant F value will be unrightly attributed to the σ_A^2-component, i.e. the treatment effect.

The problem of inflation remains when an item-analysis is performed (Table A-2). In that case, the words within treatment factor is chosen as term for the denominator of the F ratio. But with a significant F value it is not known for sure whether the treatment variance, σ_A^2, or the variance due to the Treatment x Subjects interaction, σ_{AC}^2, departs from zero, or both. The null hypothesis might be rejected, although the significant F value is due to the σ_{AC}^2-component. Thus an item-analysis has the same problem as the subject-analysis.

Calculating F_1 or F_2 gives no certainty whether σ_A^2 departs from zero, because there are always two variance components that can cause it to be significant. In Table A-3 no single error term can be found such that a significant F is solely due to the treatment variance, σ_A^2. It is possible however to combine mean squares in the numerator and in the denominator of the F ratio in such a way that they contain the same variance components, except for the treatment variance in the numerator. This F ratio is not a F ratio in the usual sense, but it is a quasi F (Winer, 1971; Kirk, 1982). Given the expected mean squares shown in Table A-3 the following quasi F can be calculated in order to decide whether there is a treatment effect:

$$(1) \qquad F' = \frac{MS_A + MS_{B(A)C}}{MS_{AC} + MS_{B(A)}}$$

In this F' ratio the numerator contains the same variance components as the denominator, except for the treatment variance, σ_A^2. The F' ratio is approximately distributed as the usual F ratio. So if its value exceeds the standard alpha value, then it can be concluded that there is an effect of the treatment variable. If the F' is significant then the investigator is confident about the reliability of the treatment effect, given the error variance of the sampled pool of subjects *and* items. In addition, the investigator has statistical evidence that the treatment effect generalizes to the populations from which the subjects and items were sampled.

A.2. Lower bound

It is seldom the case that the F' as in (1) can be computed in experimental studies with word identification tasks. In the lexical decision task there will be missing values, as reaction times to error responses are always omitted, and in the perceptual identification task there will be binary responses (1 or 0). Further, most statistical packages will have computing problems when there are too many levels on the subject and item factor. Clark (1973) has derived a lower bound to quasi F, *min* F', that is easily computed whenever it is not possible to compute the F' statistic. The *min* F' is computed with the following formula:

$$(2) \qquad MIN\ F' = \frac{F_1 \times F_2}{F_1 + F_2}$$

Given that the degrees of freedom for F_1 are equal to n and $n1$, and for F_2 equal to n and $n2$, then the degrees of freedom for the numerator of *min* F', i, are equal to n. The degrees of freedom for the denominator of *min* F', j, are computed with the following formula (3):

$$(3) \qquad j = (F_1 + F_2)^2 \,/\, \left(\frac{F_1^2}{n_2} + \frac{F_2^2}{n_1}\right)$$

If *min* F' is significant, then F' is also significant. Because F' is larger then *min* F', there is a problem if *min* F' is not significant. But as Clark has shown, the value of *min* F' does not depart grossly from F'.

A.3. What analysis to choose?

Critique (Smith, 1976; Wike and Church, 1976) has been given to the quasi *F* (and consequently the *min F′*) as being an unduly conservative test. This can be seen in formula (1), where the error term is much larger than the error terms in the subject or item analysis. The effect of conservatism is that it leads to Type II errors. A Type II error means that the test has not enough power to detect a treatment effect, i.e. when it is (wrongly) concluded that there is no treatment effect (accepting the null hypothesis), although in reality there is such an effect (the alternative hypothesis is true). In addition, Wike and Church (1976) commented that although it has an approximate *F* distribution, little is known about the characteristics of a quasi *F* distribution. The power of quasi *F* depends on a number of factors like the structure of the quasi *F*, the size of the error variance, the number of the degrees of freedom and the number of levels of the treatment variable. However, Monte Carlo simulations with the quasi *F* as in formula (1) have demonstrated that the *F′* statistic is a good approximation to the normal *F* statistic (Davenport & Webster, 1973; Forster & Dickinson, 1976). Further, as Forster and Dickinson (1976) have shown, *min F′* is a good estimate of *F′*, and both statistics are not unduly conservative, given that $\sigma_{B(A)}^2$ and σ_{AC}^2, i.e. the variance components expressing item and subject variability, are not too small. In most experiments this is likely the case.

The *F* test is robust against violations of homogeneity of variance (treatment groups have the same distribution) and normal distribution of the dependent variable. In the lexical decision task reaction time is the dependent variable, and this variable is not normally distributed. Santa, Miller and Shaw (1979) demonstrated that the *F′* and *min F′* are also robust against violations of homogeneity and distribution. They showed by means of Monte Carlo simulations, that with heterogeneous treatment group variances and with five types of error distributions (normal, exponential, log uniform, binary and log normal) the *F′* and *min F′* have real alpha values that are near the nominal alpha value of .05. Only when the variance components $\sigma_{B(A)}^2$ and σ_{AC}^2 are small, both statistics tend to be conservative.

We have discussed four types of statistical tests: F_1 (subject-analysis), F_2 (item-analysis), quasi *F* and *min F′*, i.e. the lower bound of quasi *F*. Which analysis to choose depends on how the 'subject' and stimulus material is selected. Whenever samples of subjects and items are chosen randomly or haphazardly, then the F_1 or F_2 are definitely the wrong statistics, because of the danger of inflation (Type I error). The point is that the subject and item variability, as a result of the random selection procedure, is not accounted for by the statistical models that underly the F_1 and F_2. In this situation it is best to compute the quasi F, or when this is not possible, to compute its lower bound *min* F', by applying formulas (2) and (3). The statistical model underlying quasi F has parameters that account for item and subject variability.

Sometimes investigators compute F_1 and F_2, and decide that the treatment effect is real (reject the null hypothesis) if both of these statistics are significant. Forster and Dickinson (1976) have shown with Monte Carlo simulations, that this $F_1 \times F_2$ criterium has a lower Type I error than separate F_1 or F_2 analyses, but it still has a much larger error rate than the desired rate of .05.

It is rarely the case however, that an investigator selects the stimulus material in a haphazard, nonsystematic way. Normally, items are carefully selected, and balanced on factors that correlate with the response measure. The purpose of balancing is to reduce the error variance related to the items and consequently to reduce any confounding with the treatment variable. By balancing the stimulus material, item variance is controlled for by experimental procedure, and it replaces the requirement to control by statistical procedure, i.e. applying the random effect model (quasi F). In that case F_1 is the best statistic to choose. Wickens and Keppel (1983) have shown that with balancing, the inflation that is associated with F_1 is drastically reduced. In contrast, negative bias is introduced with F', leading to an extreme reduction in power.

To reduce a possible confounding with our manipulation of the prime type factor in the Experiments 1, 2, 3 and 4, we matched all targets on word frequency and length. Several studies have shown that word frequency has a negative relationship with response latencies and an interactive relationship with repetition priming in lexical decision (Scarborough, Cortese, Scarborough, 1977; Becker, 1979; Forster and Davis, 1984; Norris, 1984).

Another way to control for confounding of item variance with the treatment effect, is to construct a master file that contains all the items that will be assigned to the treatment groups. For every subject, items are randomly selected from the master file and assigned to treatment groups. We used this procedure to assign randomly prime-target pairs to the target word conditions in the Experiments 5 through 10 (see also Durgunoglu & Neely, 1987). As Winer (1971, p. 365) has shown, in this procedure the item factor (random effect) is nested within the subject factor (also a random effect), and the treatment effect can be tested against the mean squares for the Treatment x Subject interaction.

Clark (1973) screened several psycholinguistic and semantic memory studies, carried out in the late sixties and early seventies, and concluded that these applied the wrong statistical tests. Later, in the eigthies and nineties, investigators have been aware of Clark's arguments, and correctly assumed that items, like subjects, constitute a random effect. But as it appears, instead of reporting *min* F', they reported F_1 and F_2, and rejected the null hypothesis if both statistics were significant (F_1 x F_2 criterium), or worse, if at least one them was significant. For instance, Shelton and Martin (1992) rightly remarked when reviewing the literature on automatic priming effects that: 'However, neither of these studies carried out analyses that included items as a random effect. A test for generalization across items would seem particularly important in examing the issue of priming for semantically related, unassociated pairs ... (p. 1192-1193)', but then carried out F_1 x F_2 tests in their own experiments, and said nothing about *min* F'.

Other examples are studies from the area of psycholinguistics, that investigated whether independent processing modules can be discerned that guide the syntactic processing of sentences. Stimulus material consisted of ambiguous sentences, and the main dependent variable that was used in these studies was reading time as registered by an eye movement monitor. In Experiment 1 of Rayner, Carlson and Frazier (1983): 'Both subjects (F_1) and sentences (F_2) were treated as random effects in separate analyses of total reading time (p. 363)', but for some analyses they only reported a F value, which was probably the F_1 in view of the degrees of freedom. Further, no reference was made to *min* F', and no evidence was given that the stimulus material was balanced. Ferreira and Clifton (1986) also reported separate F_1 and F_2 values, and rejected the null hypothesis when one of the values was statistically significant and the other value was almost or nearly significant. By inspection of their method section, no evidence was found for matching stimulus material in the treatment groups. Lastly, Taraban and McClelland (1988) reported analyses over subjects and over items and used the criterium of only F_1 or F_2 significance. For some of the statistical tests in the studies we reviewed, we computed *min* F' with formulas (2) and (3), with the result that the null hypothesis could not be rejected.

The effect of Clark's article has been that researchers now treat their stimulus material as a random effect, but nevertheless conduct the wrong procedure by reporting F_1 and F_2 and not *min* F'. To give some indication of this practice, we screened the volume 32 (issues 1 through 5) of the Journal of Memory and Language, and counted how many of the studies carried out the procedure of F_1 x F_2 and not *min* F'. There were a total of 35 studies, and 18 of these reported F_1 and F_2 and not *min* F'. In addition, there were 12 studies that reported only F_1 or F_2 and not *min* F'. Only two studies gave F_1, F_2 and *min* F' values. The remaining (three) studies were not relevant, because they applied correlational analyses or were theoretical in nature. Thus, these statistics clearly show that the 'F_1 x F_2'-fallacy, the one procedure that is always wrong no matter what model is assumed, is quite widespread, despite the fact that Clark's article has been a classic reference for almost 20 years.

APPENDIX B

STIMULUS MATERIALS

In this appendix the stimulus materials, that were used in all the experiments described in this thesis, is given. Table B-10 shows the 112 prime-target pairs in the master file used for the Experiments 8 and 9. The pairs 1 through 75 were also used in Experiment 5, the pairs 1 through 80 were also used in Experiment 6 and the pairs 1 through 106 were also used in Experiment 7.

Table B.1.
The Prime-Target Pairs of the SEM Condition in Experiments 1 and 2.

	Dutch		English			
	Prime	Target	Prime	Target	AF	LFT
1	aarde	grond	soil	earth	25	184
2	vraag	antwoord	question	answer	84	132
3	peper	zout	pepper	salt	83	21
4	heuvel	berg	hill	mountain	44	36
5	veter	schoen	shoelace	shoe	94	34
6	stad	dorp	town	village	37	75
7	wimpel	vlag	ribbon	flag	79	19
8	hoofd	kop	head	head	18	73
9	zilver	goud	silver	gold	75	14
10	snor	baard	moustache	beard	70	7
11	arts	dokter	physician	docter	50	97
12	moeder	vader	mother	father	48	289
13	vrede	oorlog	peace	war	44	128
14	tafel	stoel	table	chair	54	79
15	teen	voet	toe	foot	57	81
16	vlam	vuur	flame	fire	56	39
17	spijker	hamer	nail	hammer	46	3
18	oom	tante	uncle	aunt	88	27

Note. AF = Association Frequency in percentage; LFT = Language Frequency of the Target.

Table B.2.
The Prime-Target Pairs of the EPIS Condition in Experiments 1 and 2.

	Dutch		English		
	Prime	Target	Prime	Target	LFT
1	gips	kerk	gypsum	church	291
2	hagel	fluit	hail	flute	7
3	rivier	knie	river	knee	37
4	meubel	zee	furniture	sea	75
5	bijbel	lucht	bible	air	83
6	merrie	straat	mare	street	99
7	bad	touw	bath	rope	17
8	eiland	mond	island	mouth	96
9	koffie	hemel	coffee	sky	45
10	tang	blok	tongs	block	18
11	aambeeld	vogel	anvil	bird	102
12	noot	auto	nut	car	172
13	tabak	koelkast	tobacco	fridge	5
14	jas	boom	coat	tree	77
15	merg	angst	marrow	fright	70
16	beek	leger	brook	army	64
17	raket	brood	rocket	bread	31
18	gras	keuken	grass	kitchen	53

Note. LFT = Language Frequency of the Target.

Table B.3.
The Prime-Target Pairs of the NEU Condition in Experiments 1 and 2.

	Dutch		English		
	Prime	Target	Prime	Target	LFT
1	blanco	dame	blank	lady	64
2	blanco	lijn	blank	line	76
3	blanco	muziek	blank	music	78
4	blanco	maaltijd	blank	meal	23
5	blanco	bed	blank	bed	115
6	blanco	been	blank	leg	90
7	blanco	water	blank	water	193
8	blanco	kapel	blank	chapel	5
9	blanco	strand	blank	beach	28
10	blanco	reis	blank	journey	55
11	blanco	varken	blank	pig	5
12	blanco	geld	blank	money	159

Note. LFT = Language Frequency of the Target.

Table B.4.
Nonword Targets and Their Paired Primes (Translation Between Parentheses) in Experiments 1 and 2.

1. vrouw (woman) nainen
2. bezem (broom) harja
3. borst (breast) povi
4. schurk (scoundrel) lurjus
5. kwast (brush) suti
6. huid (skin) iho
7. gezicht (face) kasvot
8. paard (horse) ratsu
9. boter (butter) voi
10. schip (ship) alus
11. dijk (dike) penger
12. broek (trousers) housut
13. groente (vegetable) vihannes
14. prooi (prey) saalis
15. graan (grain) vilja
16. zalm (salmon) merilohi
17. beest (beast) elukka
18. vrucht (fruit) raakile

The next (Finnish) nonword targets were all paired to the neutral prime *blanco* (*blank*): Rusakko, kuu, sotamies, varis, taival and naru.

Table B.5.
The Pseudoword Primes and Their Definitions in Experiment 3.

kleng:	Oblong iron tool that is used in the ship building industry for pulling nails out of wood.
neper:	Four-feet mount with long hairs from Central Africa.
priel:	Low and small 18th-century tea table with thin legs.
gobbel:	Sweet Belgium pastry made of barley flour, honey, butter, milk and nuts.
lazem:	Contagious illness bringing on high fever and red spots.
turp:	Person in Icelandic mythology: Kind of hoblin with beret.
eelhok:	Crooked wooden wind-instrument.
moets:	Sour fruit with big stone.
trang:	Vegetable poisson that induces death immediately and that leaves no traces.
solliek:	A queen's or king's declaration by which a noble person is deprived of his/her title.
gakel:	Card-playing for five persons.
gork:	Three-wheeled open vehicle that is driven by an internal combustion engine.

Table B.6.
The Prime-Target Pairs of the SEM, EPIS-S⁺, EPIS-S⁻, NEU-WP and NEU-PP Conditions in Experiment 3.

Condition	Dutch Prime	Dutch Target	English Prime	English Target	LFT	AF
SEM						
1	zilver	goud	silver	gold	14	75
2	zus	broer	sister	brother	45	83
3	web	spin	web	spider	-[a]	86
4	veter	schoen	shoelace	shoe	34	94
$EPIS\text{-}S^{+}$						
1	kleng	hamer	kleng	hammer	3	
2	neper	paard	neper	horse	54	
3	priel	kast	priel	closet	24	
4	gobbel	koek	gobbel	cake	14	
$EPIS\text{-}S^{-}$						
1	lazem	tante	lazem	aunt	27	
2	turp	vork	turp	fork	8	
3	eelhok	cijfer	eelhok	digit	52	
4	moets	emmer	moets	bucket	4	
NEU-WP						
1	markt	adem	market	breath	23	
2	brug	klant	bridge	customer	32	
3	polder	vlag	polder	flag	19	
4	muis	piloot	mouse	pilot	13	
NEU-PP						
1	trang	nest	trang	nest	19	
2	solliek	lading	solliek	loading	17	
3	gakel	hout	gakel	wood	23	
4	gork	slaap	gork	sleep	27	

Note. LFT = Language Frequency of the Target; AF = Association Frequency in percentage.
[a]If no value is given for LFT, then the language frequency is less than 1 occurrence per 600,000 words.

Table B.7.
The Prime-Target Pairs of the SEM Condition in Experiment 4.

	Dutch		English			
	Prime	Target	Prime	Target	AF	LFT
1	bakker	brood	baker	bread	72	31
2	beest	dier	beast	animal	45	94
3	brand	vuur	fire	flame	63	39
4	donder	bliksem	thunder	lightning	52	7
5	duit	geld	farthing	money	62	159
6	jongen	meisje	boy	girl	82	181
7	hond	kat	dog	cat	48	18
8	kop	hoofd	head	head	39	234
9	kraan	water	faucet	water	62	193
10	kust	zee	coast	sea	41	75
11	kwast	verf	brush	paint	65	9
12	lam	schaap	lamb	sheep	57	8
13	maan	zon	moon	sun	54	49
14	neef	nicht	cousin	cousin	85	8
15	peer	appel	pear	apple	53	11
16	peper	zout	pepper	salt	83	21
17	pijl	boog	arrow	bow	66	12
18	stam	boom	stem	tree	78	77
19	storm	wind	storm	wind	48	48
20	tafel	stoel	table	chair	54	79
21	teen	voet	toe	foot	57	81
22	vork	mes	fork	knife	51	11
23	vraag	antwoord	question	answer	84	132
24	web	spin	web	spider	86	-[a]
25	zilver	goud	silver	gold	75	14

Note. AF = Association Frequency in percentage; LFT = Language Frequency of the Target.
[a]If no value is given for LFT, then the language frequency is less than 1 occurrence per 600,000 words.

Table B.8.
The Prime-Target Pairs of the NEU (Changed Pairs) Condition in Experiment 4.

	Dutch		English		
	Prime	Target	Prime	Target	LFT
1	tijger	vader	tiger	father	289
2	angst	koffie	fright	coffee	73
3	hart	spijker	heart	nail	7
4	bord	rad	plate	wheel	-[a]
5	vlam	jurk	flame	dress	10
6	kip	gort	chicken	groats	-
7	neus	dorp	nose	village	75
8	duim	blad	thumb	leaf	85
9	haas	plank	hare	board	20
10	liefde	grond	love	soil	184
11	druppel	nummer	drop	number	53
12	dood	bed	death	bed	115
13	palm	reis	palm	journey	55
14	hemel	tak	sky	branch	19
15	lente	soldaat	spring	soldier	57
16	kool	been	cabbage	leg	90
17	vloer	kerk	floor	church	291
18	krent	slag	currant	hit	45
19	haar	sla	hair	lettuce	-
20	hel	koek	hell	cake	14
21	touw	muis	rope	mouse	6
22	hout	leger	wood	army	64
23	traan	papier	tear	paper	58
24	boezem	dadel	bosom	date	-
25	mond	oester	mouth	oyster	-

Note. LFT = Language Frequency of the Target.
[a]If no value is given for LFT, then the language frequency is less than 1 occurrence per 600,000 words.

Table B.9.
The Prime-Target Pairs of the EPIS Condition in Experiment 4.

	Dutch		English		
	Prime	Target	Prime	Target	LFT
1	raket	arm	rocket	arm	24
2	schip	bloesem	ship	blossom	76
3	fiets	boek	bicycle	book	221
4	zuster	boter	sister	butter	24
5	stad	deur	town	door	166
6	kleed	diepte	garment	depth	24
7	tol	eiland	toll	island	36
8	vinger	glas	finger	glass	68
9	katoen	hand	cotton	hand	458
10	maag	kaper	stomach	raider	-[a]
11	zoon	kleur	son	colour	12
12	straat	krijt	street	chalk	-
13	boei	lijn	buoy	line	76
14	kist	lucht	chest	air	83
15	jas	mot	coat	moth	-
16	rivier	monnik	river	monk	10
17	buik	pen	belly	pen	11
18	veld	raam	field	window	83
19	breuk	roos	fault	rose	14
20	regen	tand	rain	tooth	25
21	vlees	trein	meat	train	44
22	muur	vijg	wall	fig	-
23	hoed	vis	hat	fish	42
24	naald	vracht	needle	freight	-
25	dam	wagen	dam	wagon	46

Note. LFT = Language Frequency of the Target.
[a]If no value is given for LFT, then the language frequency is less than 1 occurrence per 600,000 words.

The extralist primes that were used in Experiment 6 (translation between parentheses) are: Afgrond (abyss), balk (balk), banaan (banana), breuk (fault), draak (dragon), eiland (island), hooiberg (hay-stack), kever (beetle), koelkast (fridge), lading (load), lucht (air), mat (mat), lijn (line), oester (oyster), pastoor (pastor), pen (pen), stier (bull), vaas (vase), winkel (shop), ziel (soul).

Table B.10.

The Prime-Target Pairs in the Master Files of Experiments 5, 6, 7, 8 and 9.

	Dutch		English			
	Prime	Target	Prime	Target	AF	LFT
1	majoor	leger	major	army	42	64
2	man	vrouw	man	woman	87	585
3	merel	vogel	blackbird	bird	56	102
4	merg	been	marrow	leg	54	90
5	neef	nicht	cousin	cousin	85	8
6	adder	gras	adder	grass	52	23
7	oom	tante	uncle	aunt	88	27
8	oorlog	vrede	war	peace	46	55
9	peer	appel	pear	apple	53	11
10	peper	zout	pepper	salt	83	21
11	pijl	boog	arrow	bow	66	12
12	rover	dief	robber	thief	36	-[a]
13	rozijn	krent	raisin	currant	67	-
14	slager	vlees	butcher	meat	79	41
15	snor	baard	moustache	beard	70	13
16	spaak	wiel	spoke	wheel	61	5
17	spijker	hamer	nail	hammer	46	3
18	staal	ijzer	steel	iron	44	6
19	stam	boom	stem	tree	78	77
20	ster	hemel	star	sky	36	45
21	storm	wind	storm	wind	48	48
22	tafel	stoel	table	chair	54	79
23	teen	voet	toe	foot	57	81
24	thee	koffie	tea	coffee	57	73
25	tijger	leeuw	tiger	lion	41	12
26	vader	moeder	father	mother	83	324
27	vallei	dal	glen	valley	48	-
28	venster	raam	window	window	58	83

Note. AF = Association Frequency in percentage; LFT = Language Frequency of the Target.

[a]If no value is given for LFT, then the language frequency is less than 1 occurrence per 600,000 words.

Table B.10. *Continued.*

	Dutch		English			
	Prime	Target	Prime	Target	AF	LFT
29	veter	schoen	shoelace	shoe	94	34
30	veulen	paard	foal	horse	64	54
31	vork	mes	fork	knife	51	11
32	vraag	antwoord	question	answer	84	132
33	vrees	angst	fear	fright	82	70
34	web	spin	web	spider	86	-[a]
35	wimpel	vlag	ribbon	flag	79	19
36	wiek	molen	wing	mill	84	15
37	zilver	goud	silver	gold	75	14
38	zoon	dochter	son	daugther	63	79
39	zus	broer	sister	brother	83	45
40	zwijn	varken	swine	pig	61	5
41	arts	dokter	physician	doctor	50	97
42	bakker	brood	baker	bread	72	31
43	beest	dier	beast	animal	45	94
44	bek	mond	mouth	mouth	45	96
45	boezem	borst	bosom	breast	39	28
46	brand	vuur	fire	flame	63	39
47	dadel	vijg	date	fig	32	-
48	dag	nacht	day	night	60	139
49	dame	heer	lady	gentleman	57	393
50	deksel	pan	lid	pan	55	16
51	donder	bliksem	thunder	lightning	52	7
52	dorp	stad	village	town	49	198
53	draad	naald	thread	needle	33	6
54	drank	bier	beverage	beer	33	22
55	duim	vinger	thumb	finger	45	46
56	duit	geld	farthing	money	62	159

Note. AF = Association Frequency in percentage; LFT = Language Frequency of the Target.
[a]If no value is given for LFT, then the language frequency is less than 1 occurrence per 600,000 words.

Table B.10. *Continued.*

	Dutch		English			
	Prime	Target	Prime	Target	AF	LFT
57	gesp	riem	buckle	belt	51	5
58	haan	kip	cock	chicken	67	19
59	haas	konijn	hare	rabbit	62	6
60	hagel	sneeuw	hail	snow	40	7
61	haven	schip	harbour	ship	37	119
62	haver	gort	oats	groats	40	-[a]
63	heuvel	berg	hill	mountain	44	36
64	hond	kat	dog	cat	48	18
65	jongen	meisje	boy	girl	82	181
66	kaf	koren	chaff	corn	87	-
67	kalf	koe	calf	cow	74	5
68	kapel	kerk	chapel	church	48	291
69	kapstok	jas	coat-hook	coat	73	31
70	kei	steen	boulder	stone	67	43
71	keizer	koning	emperor	king	53	55
72	kies	tand	tooth	tooth	43	25
73	kink	kabel	hitch	cable	82	7
74	kogel	geweer	bullit	rifle	35	22
75	kop	hoofd	head	head	39	234
76	kous	sok	stocking	sock	43	4
77	kraan	water	faucet	water	62	193
78	kwast	verf	brush	paint	65	9
79	lam	schaap	lamb	sheep	57	8
80	maan	zon	moon	sun	54	49
81	aanrecht	keuken	sink	kitchen	21	53
82	grond	aarde	soil	earth	27	60
83	bever	dam	beaver	dam	22	16
84	boord	kraag	collar	collar	23	10

Note. AF = Association Frequency in percentage; LFT = Language Frequency of the Target.
[a]If no value is given for LFT, then the language frequency is less than 1 occurrence per 600,000 words.

Table B.10. *Continued.*

	Dutch		English			
	Prime	Target	Prime	Target	AF	LFT
85	brok	keel	lump	throat	32	31
86	darm	maag	gut	stomach	13	13
87	sjaal	das	shawl	tie	27	8
88	sla	groente	lettuce	vegetable	34	13
89	wolk	regen	cloud	rain	28	32
90	jurk	rok	dress	skirt	29	22
91	steel	bezem	handle	broom	32	-[a]
92	pij	monnik	habit	monk	40	10
93	streep	lijn	stripe	line	40	76
94	korf	mand	hamper	basket	42	5
95	koffer	reis	suit-case	journey	24	55
96	kever	tor	beetle	beetle	29	-
97	katoen	wol	cotton	wool	19	6
98	kaper	kust	raider	coast	33	34
99	mosterd	maaltijd	mustard	meal	33	23
100	stro	hooi	straw	hay	26	4
101	potlood	pen	pencil	pen	41	11
102	doorn	roos	thorn	rose	30	14
103	karton	doos	cardboard	box	36	12
104	aap	noot	monkey	nut	30	-
105	linnen	laken	linen	sheet	18	9
106	hemd	broek	shirt	trousers	23	27
107	karper	vis	carp	fish	78	42
108	kameraad	vriend	mate	friend	66	123
109	dressoir	kast	sideboard	closet	38	24
110	burcht	kasteel	citadel	castle	50	24
111	kalmte	rust	calmness	rest	35	85
112	elleboog	arm	elbow	arm	36	89

Note. AF = Association Frequency in percentage; LFT = Language Frequency of the Target.
[a]If no value is given for LFT, then the language frequency is less than 1 occurrence per 600,000 words.

The nonword targets in Experiments 8 and 9 were: Lazem, kleng, solliek, gakel, gork, priel, turp, gobbel, trang, neper, moets, brol, zwert, hampaat, kasvot, penger, vihannes, lurjus, alus, ele, aro, telki, piennar, sauma, polveke, jono, mesi, halu, kela, rikos and mela.

Table B.11.

The Word Triplets in the Master File of Experiment 10.

	Prime-s	Prime-w	Target	AF-s	AF-w	LFT
1	dorp	straat	stad	49.0	1.0	198
	village	street	town			
2	duim	teen	vinger	45.0	1.0	46
	thumb	toe	finger			
3	koe	gort	melk	44.0	1.0	15
	cow	groats	milk			
4	streep	draad	lijn	42.0	1.0	76
	stripe	thread	line			
5	neef	oom	nicht	85.0	1.0	8
	cousin	uncle	cousin			
6	kuip	kraan	bad	39.0	1.0	11
	tub	faucet	bath			
7	wimpel	stok	vlag	79.0	1.0	19
	ribbon	stick	flag			
8	snor	haar	baard	70.0	1.0	13
	moustache	hair	beard			
9	pijl	poort	boog	66.0	1.0	12
	arrow	gate	bow			
10	spijker	plank	hamer	46.0	1.0	3
	nail	board	hammer			
11	rozijn	koek	krent	67.0	1.0	-[a]
	raisin	cake	currant			
12	korf	riet	mand	42.0	1.0	5
	hamper	reed	basket			
13	steel	emmer	bezem	32.0	2.0	-
	handle	bucket	broom			
14	vallei	vlakte	dal	48.0	2.0	-
	glen	plain	valley			

Note. Prime-s = Strongly Related Prime; Prime-w = Weakly Related Prime; AF-s = Association Frequency of Strong Relationship; AF-w = Association Frequency of Weak Relationship; LFT = Language Frequency of the Target.

[a]If no value is given for LFT, then the language frequency is less than 1 occurrence per 600,000 words.

Table B.11. *Continued.*

	Prime-s	Prime-w	Target	AF-s	AF-w	LFT
15	heuvel	zand	berg	44.0	2.0	36
	hill	sand	mountain			
16	peer	banaan	appel	53.0	2.0	11
	pear	banana	apple			
17	jurk	mantel	rok	29.0	2.0	22
	dress	mantle	skirt			
18	tafel	bed	stoel	54.0	2.0	79
	table	bed	chair			
19	tor	insekt	kever	30.0	2.0	-[a]
	beetle	insect	beetle			
20	kink	touw	kabel	82.0	2.0	7
	hitch	rope	cable			
21	bloesem	lam	lente	29.0	2.0	-
	blossom	lamb	spring			
22	wond	naald	pijn	28.5	2.0	54
	wound	needle	pain			
23	maan	hemel	zon	54.0	2.0	49
	moon	sky	sun			
24	bakker	maaltijd	brood	72.0	2.0	31
	baker	meal	bread			
25	koren	stro	graan	24.0	2.0	7
	corn	straw	grain			
26	donder	storm	bliksem	52.0	2.0	7
	thunder	storm	lightning			
27	haven	zee	schip	37.0	2.0	119
	harbour	sea	ship			
28	schaap	linnen	wol	26.0	2.0	6
	sheep	linen	wool			
29	rover	bedrog	dief	36.0	2.0	-
	robber	fraud	thief			

Note. Prime-s = Strongly Related Prime; Prime-w = Weakly Related Prime; AF-s = Association Frequency of Strong Relationship; AF-w = Association Frequency of Weak Relationship; LFT = Language Frequency of the Target.

[a]If no value is given for LFT, then the language frequency is less than 1 occurrence per 600,000 words.

Table B.11. *Continued.*

	Prime-s	Prime-w	Target	AF-s	AF-w	LFT
30	doorn	knop	roos	30.0	2.0	14
	thorn	bud	rose			
31	majoor	kogel	leger	42.0	2.0	64
	major	bullit	army			
32	peper	spek	zout	83.0	2.0	21
	pepper	bacon	salt			
33	haas	veld	konijn	62.0	2.0	6
	hare	field	rabbit			
34	pij	priester	monnik	40.0	3.0	10
	habit	priest	monk			
35	duit	klant	geld	62.0	3.0	159
	farthing	customer	money			
36	zwijn	modder	varken	61.0	3.0	5
	swine	mud	pig			
37	kies	tong	tand	43.0	3.0	25
	tooth	tongue	tooth			
38	keizer	leeuw	koning	53.0	3.0	55
	emperor	lion	king			
39	riem	been	broek	51.0	3.0	27
	belt	leg	trousers			
40	kapstok	hemd	jas	73.0	3.0	31
	coat-hook	shirt	coat			
41	grond	pot	aarde	27.0	3.0	60
	soil	pot	earth			
42	dame	hoed	heer	57.0	3.0	393
	lady	hat	gentleman			
43	deksel	aanrecht	pan	55.0	3.0	16
	lid	sink	pan			
44	slager	kluif	vlees	79.0	3.0	41
	butcher	bone	meat			

Note. Prime-s = Strongly Related Prime; Prime-w = Weakly Related Prime; AF-s = Association Frequency of Strong Relationship; AF-w = Association Frequency of Weak Relationship; LFT = Language Frequency of the Target.

Table B.11. *Continued.*

	Prime-s	Prime-w	Target	AF-s	AF-w	LFT
45	wiek	polder	molen	84.0	3.0	15
	wing	polder	mill			
46	goud	kraai	zilver	44.0	3.0	10
	gold	crow	silver			
47	stam	aap	boom	78.0	3.0	77
	stem	monkey	tree			
48	brand	water	vuur	63.0	4.0	39
	fire	water	fire			
49	vrede	geweer	oorlog	44.0	4.0	128
	peace	rifle	war			
50	staal	aambeeld	ijzer	44.0	4.0	6
	steel	anvil	iron			
51	koffer	strand	vakantie	15.0	4.0	38
	suit-case	beach	holiday			
52	haan	veer	kip	67.0	4.0	19
	cock	feather	chicken			
53	hagel	regen	sneeuw	40.0	4.0	7
	hail	rain	snow			
54	kwast	muur	verf	65.0	4.0	9
	brush	wall	paint			
55	nest	lucht	vogel	55.0	4.0	102
	nest	air	bird			
56	tabak	rook	pijp	26.0	4.0	22
	tobacco	smoke	pipe			
57	honger	woestijn	dorst	30.0	4.0	11
	hunger	desert	thirst			
58	web	vlieg	spin	86.0	5.0	-[a]
	web	fly	spider			
59	drank	koelkast	bier	33.0	5.0	22
	beverage	fridge	beer			

Note. Prime-s = Strongly Related Prime; Prime-w = Weakly Related Prime; AF-s = Association Frequency of Strong Relationship; AF-w = Association Frequency of Weak Relationship; LFT = Language Frequency of the Target.

[a]If no value is given for LFT, then the language frequency is less than 1 occurrence per 600,000 words.

Table B.11. *Continued.*

	Prime-s	Prime-w	Target	AF-s	AF-w	LFT
60	sla	wortel	groente	34.0	5.0	13
	lettuce	carrot	vegetable			
61	vader	zoon	moeder	83.0	5.0	324
	father	son	mother			
62	thee	suiker	koffie	73.0	5.0	73
	thea	sugar	coffee			
63	veulen	wei	paard	64.0	5.0	54
	foal	pasture	horse			
64	kapel	bijbel	kerk	48.0	6.0	291
	chapel	bible	church			
65	man	meisje	vrouw	87.0	6.0	585
	man	girl	woman			
66	adder	tuin	gras	52.0	6.0	23
	adder	garden	grass			
67	kat	hond	poes	30.0	6.0	8
	cat	dog	puss			
68	gans	snavel	eend	28.0	6.0	5
	goose	bill	duck			
69	boezem	buik	borst	39.0	6.0	28
	bosom	belly	breast			
70	zus	zwager	broer	39.3	4.7	45
	sister	brother-in-law	brother			
71	vrees	woede	angst	49.7	2.7	70
	fear	rage	fright			
72	monteur	fiets	auto	44.7	2.0	172
	mechanic	bicycle	car			
73	chef	slaaf	baas	47.3	1.0	37
	chief	slave	boss			
74	berouw	zonde	spijt	48.7	1.3	15
	repentance	sin	regret			
75	zwart	kleur	wit	44.3	4.7	144
	black	colour	white			

Note. Prime-s = Strongly Related Prime; Prime-w = Weakly Related Prime; AF-s = Association Frequency of Strong Relationship; AF-w = Association Frequency of Weak Relationship; LFT = Language Frequency of the Target.

Table B.11. *Continued.*

	Prime-s	Prime-w	Target	AF-s	AF-w	LFT
76	drempel	raam	deur	35.7	3.3	166
	doorstep	window	door			
77	kameraad	gast	vriend	66.0	1.0	123
	mate	guest	friend			
78	kop	oor	hoofd	28.7	3.0	234
	head	ear	head			
79	elfje	koets	sprookje	42.0	3.0	10
	fairy	coach	fairy-tale			
80	lepel	bord	vork	39.3	3.3	8
	spoon	plate	fork			
81	drop	taart	snoep	24.0	1.0	2
	liquorice	tart	candy			
82	rasp	boter	kaas	23.7	4.7	24
	rasp	butter	cheese			
83	regel	wil	zin	27.0	3.0	204
	rule	will	sense			
84	inkt	buro	pen	35.3	1.7	11
	ink	desk	pen			
85	plan	gedachte	idee	36.7	5.7	119
	plan	thought	idea			
86	visioen	waan	droom	27.0	2.0	27
	vision	delusion	dream			
87	misdaad	agressie	moord	28.0	1.0	40
	crime	agression	murder			
88	harp	ballet	muziek	32.3	1.7	78
	harp	ballet	music			
89	week	eeuw	dag	41.0	2.0	554
	week	age	day			
90	burcht	krot	kasteel	50.0	2.0	24
	citadel	hovel	castle			
91	zerk	dood	graf	39.0	4.5	9
	tombstone	death	grave			

Note. Prime-s = Strongly Related Prime; Prime-w = Weakly Related Prime; AF-s = Association Frequency of Strong Relationship; AF-w = Association Frequency of Weak Relationship; LFT = Language Frequency of the Target.

SAMENVATTING

De centrale vraagstelling in dit proefschrift is onder welke leercondities de vorming van nieuwe associaties in het semantisch geheugen plaatsvindt. Er worden 10 experimenten besproken waarin de condities onderzocht werden die voldoende zijn voor het vinden van automatisch semantische priming bij nieuw-geleerde associaties in twee geheugentaken: Lexicale decisie en perceptuele identificatie.

In **Hoofdstuk** 1 wordt een korte kenschets gegeven van het onderscheid tussen het episodisch en semantisch geheugen zoals oorspronkelijk door Tulving (1972, 1983) beschreven. In het episodisch geheugen is informatie opgeslagen omtrent datgene wat iemand persoonlijk heeft meegemaakt, aangeduid als gebeurtenis of episode. Episodische informatie is contextafhankelijk, d.w.z. het ophalen van de informatie is sterk gebonden aan de tijd en plaats van opslag van de informatie. In het semantisch geheugen is informatie terug te vinden omtrent de kennis en betekenis van woorden. Deze informatie is contextonafhankelijk. Tulving veronderstelde dat in beide geheugensystemen ook associaties zijn gerepresenteerd, waarbij episodische associaties de tijd-ruimtelijke aspecten van gebeurtenissen representeren en semantische associaties de overlap in betekenis tussen woorden. Dezelfde onderverdeling in semantisch en episodisch maakte Tulving ook met betrekking tot geheugentaken. In semantische geheugentaken zoals lexicale decisie en perceptuele identificatie blijkt dat de verwerking van een woord (het target) gefaciliteerd wordt indien het voorafgegaan wordt door een ander woord (de prime) dat daarmee semantisch geassocieerd is. Dit effect, dat semantische priming wordt genoemd, is automatisch indien de Stimulus Onset Asynchrony tussen de prime en het target kleiner is dan 250 milliseconden. In alle experimenten werd het automatisch semantische priming effect als leercriterium gehanteerd. Als bij een nieuw-geleerde associatie dezelfde functionele priming wordt gevonden als bij een bestaande associatie dan is dit een indicatie voor semantisch leren. Verder zou dan ook moeten blijken dat het effect bij de nieuwe associaties contextonafhankelijk is. Dit vormt immers per definitie een eigenschap van het semantisch geheugen. Uitgangspunt van ons onderzoek is het paradigma van Salasoo, Shiffrin en Feustel (1985), waarin aangetoond werd dat vijf presentaties van een pseudowoord reeds voldoende waren voor de vorming van een nieuwe woordcode in het semantisch geheugen. Voorts bleek bleek dat de perceptuele identificatie van de nieuwe woordcode na een jaar nog steeds functioneel gelijk was aan die van een bestaand woord. De assumptie is dat de vorming van een nieuwe semantische associatie ook gebaseerd is op episodische leerervaringen. De verwachting is dat er vier verschillende leereffecten zullen optreden indien woordparen herhaaldelijk als prime-target paren in een semantische geheugentaak worden aangeboden. Deze leereffecten kunnen worden aangetoond indien er drie verschillende condities van prime-target paren zijn. Dit zijn achtereenvolgens een conditie met preexperimenteel gerelateerde prime-target paren (SEM conditie), een conditie met preexperimenteel ongerelateerde prime-target paren (EPIS conditie) en een neutrale conditie waarin verhinderd wordt dat er tijdens het experiment een associatie gevormd wordt tussen de prime en target (NEU conditie). Een neutrale conditie kan op twee manieren geconstrueerd worden. Ten eerste door elk target vooraf te laten gaan door hetzelfde, qua betekenis, neutrale woord *blanco*. Of door op iedere presentatie een nieuwe koppeling te maken tussen de primes en targets van de NEU conditie (wisselparen). Het eerste leereffect dat verwacht wordt is *semantische priming*. Dit betekent dat op de eerste presentatie de SEM conditie facilitatie vertoont ten opzichte van de EPIS and NEU condities. Het tweede effect is *repetition priming*. Bij herhaalde aanbieding in een semantische geheugentaak zal er voor een target facilitatie optreden onafhankelijk van de prime die er aan voorafgaat. De verwachting is dat dit effect in alle drie de condities (SEM, EPIS en NEU) zal optreden. Het derde leereffect is *episodische priming*, een effect als gevolg van een associatie die tijdens een experiment geleerd is, waarbij dan facilitatie optreedt in de SEM en EPIS condities ten opzichte van de NEU conditie. Tenslotte wordt een leereffect verwacht indien de nieuw-geleerde associaties van de EPIS conditie toegevoegd worden aan het semantisch geheugen. Relatief zal er dan meer facilitatie in de EPIS conditie zijn ten opzichte van de SEM conditie. De interactie tussen de EPIS en de SEM conditie vormt dan het criterium voor semantisch leren.

In **Hoofdstuk 2** worden drie experimenten besproken waarin woordparen herhaaldelijk als prime-target paren in de lexicale decisietaak werden aangeboden. In geen enkel experiment werd evidentie voor semantisch leren gevonden. In Experiment 1 werden prime-target paren enkel herhaald (16 presentaties verspreid over vier dagen) zonder verdere leerinstructie. Er werd gevonden dat de lexicale decisietijden voor de targets in de EPIS conditie relatief sneller werden dan die in de NEU conditie. Deze facilitatie werd niet gevonden voor de targets in de SEM conditie. In Experiment 2 werd na iedere presentatie in de lexicale decisietaak een gepaarde associatietaak toegevoegd, met de bedoeling dat de proefpersonen de prime-target paren nu ook expliciet zouden leren. Zowel de targets in de EPIS als in de SEM conditie werden gefaciliteerd ten opzichte van de NEU conditie. Hoewel er geen sprake was van semantisch leren, bleek er in Experiment 1 en 2 wel een episodisch priming effect te zijn opgetreden. Dat in beide experimenten geen evidentie werd gevonden voor toevoeging van de nieuw-geleerde associaties aan het semantisch geheugen kan de volgende oorzaak hebben. Een woord in het semantisch geheugen heeft vele associatieve verbindingen met andere woorden met als gevolg dat deze verbindingen gaan interfereren bij de vorming van een nieuwe associatie. In Experiment 3 werden daarom aan de proefpersonen eerst nieuwe woorden geleerd, ieder met een eigen semantische definitie, met als doel om vanuit deze nieuwe woorden een semantische associatie te kunnen creëren zonder het nadeel van interfererende associaties. Na het leren van de semantische definities werden de nieuwe woorden als primes gekoppeld aan een woordtarget om vervolgens herhaaldelijk (12 presentaties verspreid over twee dagen) aangeboden te worden in de lexicale decisietaak. Er werd geen expliciete leerinstructie gegeven, maar de proefpersonen moesten op elke presentatie een zin genereren met de prime en target. Deze manipulaties leidden niet tot semantisch leren. Er was ook geen evidentie voor episodische priming.

In alle experimenten die in **Hoofdstuk 3** worden besproken, werden woordparen herhaaldelijk als prime-target paren in de perceptuele identificatietaak aangeboden. In de Experimenten 4 en 5, die qua design en leercondities het meeste overeenkwamen met respectievelijk de Experimenten 1 en 2, werd noch een indicatie voor episodisch leren, noch voor semantisch leren gevonden. In Experiment 6 (maar ook in latere experimenten) werd het onderzoeksdesign uitgebreid. Prime-target paren aangeboden tijdens een leerfase werden in een aansluitende testfase vergeleken met niet-aangeboden prime-target paren. Zowel voor bestaande associaties (SEM conditie) alsook voor nieuw-geleerde associaties (EPIS conditie) werd episodische priming gevonden. Echter, er werd geen evidentie gevonden dat de nieuw-geleerde associaties aan het semantisch geheugen toegevoegd waren. In Experiment 7 werden de resultaten van Experiment 6 gerepliceerd. Het verschil tussen beide experimenten was dat in Experiment 6 niet, en in Experiment 7 wel een NEU conditie met wisselparen aan de leerfase was toegevoegd. Verder hadden de proefpersonen in Experiment 7 een expliciete leerinstructie gekregen om de prime-target paren te leren voor een latere geheugentaak. In Experiment 6 was deze leerinstructie niet gegeven.

In de drie experimenten behandeld in **Hoofdstuk 4** werd de rol van context bij episodisch en semantisch leren nader bekeken. In de leerfasen van deze experimenten werden woordparen herhaaldelijk aangeboden als prime-target paren in lexicale decisie (Experiment 8), of als gepaarde associaties voor een latere geheugentest (Experiment 9), of als beide (Experiment 10). In elke testfase werden de bestudeerde prime-target paren vergeleken met nieuwe prime-target paren zowel in lexicale decisie als in perceptuele identificatie. In de Experimenten 8 en 9 werd geen indicatie gevonden voor semantisch leren, maar er trad wel episodische priming op in zowel de EPIS als de SEM conditie. Verder bleek dit leereffect in beide condities contextafhankelijk te zijn. In de testfase van Experiment 8 trad alleen episodische priming op in de lexicale decisietaak, nadat de bestudeerde prime-target paren tijdens de leerfase in dezelfde lexicale decisietaak aangeboden waren. Het contextafhankelijke leren in dit experiment wijst dus in de richting van overeenkomsten in taakprocedures in de leer- en testfase. In de testfase van Experiment 9 werd alleen episodische priming in de perceptuele identificatietaak gevonden. Echter, het contextafhankelijke leren dat in dit experiment werd gevonden, is niet terug te voeren op overeenkomsten in taakprocedures, omdat de bestudeerde prime-target paren enkel als gepaarde associaties werden aangeboden. De contextafhankelijkheid in Experiment 9 lijkt eerder verklaard te kunnen worden door het medium waarmee het stimulusmateriaal werd aangeboden, namelijk een tachistoscoop, en door de uiterlijke kenmerken van het stimulusmateriaal zoals letterfont, lettergrootte en letterkleur. In Experiment 10 werd voor de eerste keer evidentie gevonden dat de nieuw-geleerde associaties aan het semantisch geheugen werden toegevoegd. Op de derde dag tijdens de leerfase werden de lexicale decisietijden in de EPIS conditie relatief meer gefaciliteerd dan die in de SEM conditie. De verklaring dat in de SEM conditie een bodem bereikt was lijkt niet op te gaan, omdat de lexicale decisietijden in deze conditie nog steeds bleven dalen. Additionele evidentie voor semantisch leren werd ook in de testfase van Experiment 10 gevonden. Het leereffect voor de EPIS conditie in de lexicale decisietaak vertoonde transfer naar de perceptuele identificatietaak. Transfer voor semantische associaties wordt verwacht omdat deze contextonafhankelijk zijn. Transfer werd niet gevonden voor de SEM conditie. Het lijkt daarom aannemelijk dat in Experiment 10 een bestaande associatie niet verder versterkt werd, maar dat er een episodische code voor deze associatie werd gevormd.

Hoofdstuk 5 bevat de conclusies en de implicaties van het onderzoek. Er werd alleen in Experiment 10 evidentie gevonden voor semantisch leren en dit pas op de derde dag van de leerfase van het experiment. Dit duidt erop dat in tegenstelling tot de vorming van een nieuwe woordcode (Salasoo, Shiffrin en Feustel, 1985), de vorming van een nieuwe code voor de semantische associatie tussen twee woorden veel meer leren vergt. Hoewel dus maar in een experiment evidentie werd gevonden voor semantisch leren, is een van de conclusies dat het in dit proefschrift ontwikkelde paradigma geschikt lijkt om de vorming van nieuwe, semantische associaties te bestuderen. Van belang daarbij is dat men het juiste criterium hanteert bij de beslissing dat er sprake is van semantisch leren. In eerder onderzoek is dit aspect verwaarloosd. In Hoofdstuk 5 worden ook de condities beschreven die voldoende zijn voor het vinden van episodische priming in lexicale decisie en perceptuele identificatie. Dit sluit aan bij wat in eerder onderzoek is gevonden. Een belangrijk resultaat van het onderzoek is verder dat er aangetoond is dat episodische priming contextafhankelijk, en semantisch leren contextonafhankelijk is. Context(on)afhankelijkheid is daarmee een eigenschap die binnen het in dit onderzoek ontwikkelde paradigma aanvullende informatie kan geven omtrent de aard van de gevonden leereffecten. Hoewel het geen primaire vraagstelling was in het onderhavige onderzoek geven de resultaten van de experimenten een verdere aanwijzing dat het episodisch en semantisch geheugen niet functioneel gescheiden zijn. In twee semantische geheugentaken, lexicale decisie en perceptuele identificatie, werd gevonden dat een woord automatisch geactiveerd wordt door een episodische associatie. Een conclusie in Hoofdstuk 5 is verder dat door de inductieve aard van het onderzoek de resultaten op dit moment enkel nog door een globaal model (Salasoo, Shiffrin en Feustel, 1985) beschreven kunnen worden. De Compound Cue theorie van Ratcliff en McKoon (1988) biedt echter aanknopingspunten voor mathematische modelvorming. Een laatste conclusie is dat het gevonden leereffect bij episodische associaties in combinatie met de problemen die er bestaan met het vinden van facilitatie bij semantisch gerelateerde, maar niet geassocieerde woordparen in lexicale decisie zoals beschreven in de literatuur, erop duidt dat er geen exclusief semantisch netwerk bestaat onafhankelijk van een semantisch geheugen gebaseerd op associaties.

In **Appendix A** wordt verantwoording gegeven over de statistische analyses van de experimenten beschreven in dit proefschrift. Verder wordt geprobeerd om meer inzicht te krijgen in de verwarring die is ontstaan na het verschijnen van Clark's artikel in 1973, waarin gepleit werd voor het gebruik van de *min F'* toetsingsgrootheid. Clark's argument was dat in experimenten op het gebied van de psycholinguïstiek en het semantisch geheugen niet alleen subjecten als een random effect beschouwd moeten worden, maar ook het stimulusmateriaal in verband met het generaliseren van de onderzoeksresultaten naar taal in het algemeen. Analyse van het stimulusmateriaal als een fixed effect leidt tot Type I fouten (inflatie). In Appendix A wordt verduidelijkt dat uitvoering van de juiste statistische procedure in 'talig' onderzoek afhankelijk is van hoe men wenst te controleren voor itemvariantie: Statistisch of experimenteel. In elk geval is uitvoering van de 'F_1 x F_2' procedure, dat wil zeggen significante resultaten gebaseerd op zowel een subject-analyse als een item-analyse, onjuist. Argumenten hiervoor worden onderbouwd met wat er bekend is van Monte Carlo simulaties op dit gebied en met een aantal case studies.

Allport, D.A. (1977). On knowing the meaning of words we are unable to report: The effects of visual masking. In: S. Dornic (Ed.), *Attention and performance VI* (pp. 505-533). Hillsdale, N.J.: Erlbaum.

Anderson, J.R. (1983). A spreading activation theory of memory. *Journal of Verbal Learning and Verbal Behavior*, *22*, 261-295.

Anderson, J.R., & Bower, G.H. (1973). *Human associative memory*. Washington, D.C.: Winston.

Anderson, J.R., & Ross, B.H. (1980). Evidence against a semantic-episodic distinction. *Journal of Experimental Psychology: Human Learning and Memory*, *6*, 441-466.

Atkinson, R.C., Herrmann, D.J., & Wescourt, K.T. (1974). Search processes in recognition memory. In: R.L. Solso (Ed.), *Theories in cognitive psychology: The Loyola symposium* (pp. 101-146). Hillsdale, N.J.: Erlbaum.

Barsalou, L.W. (1982). Context-independent and context-dependent information in concepts. *Memory and Cognition*, *10*, 82-93.

Becker, C.A. (1979). Semantic context and word frequency effects in visual word recognition. *Journal of Experimental Psychology: Human Perception and Performance*, *5*, 252-259.

Becker, C.A. (1980). Semantic context effects in visual word recognition: An analysis of semantic strategies. *Memory and Cognition*, *6*, 493-512.

Bransford, J.D. (1979). *Human cognition: Learning, understanding, and remembering*. Belmont, CA: Wadsworth Publishing Company.

Brysbaert, M., Bovens, N., d'Ydewalle, G., & Van Calster, J. (1989). Turbo Pascal timing routines for the IBM microcomputer family. *Behavior Research Methods, Instruments, & Computers*, *21*, 73-83.

Bush, R.R. (1963). Estimation and evaluation. In: R.D. Luce, R.R. Bush & E. Galanter (Eds.), *Handbook of Mathematical Psychology, Volume I* (pp. 429-469). New York: John Wiley and Sons, Inc.

Cañas, J.J. (1990). Associative strength effects in the lexical decision task. *The Quarterly Journal of Experimental Psychology*, *42A*, 121-145.

Carr, T.H., Dagenbach, D., VanWieren, D., Radvansky, L.A., Alejano, A.R., & Brown, J.S. (in press). Acquiring general knowledge from specific episodes of experience. In C. Umilta & M. Moscovitch (Eds.), *Attention and Performance XV: Conscious and nonconscious information processing*. Cambridge, Mass: The MIT Press.

Carroll, M., & Kirsner, K. (1982). Context and repetition effects in lexical decision and recognition memory. *Journal of Verbal Learning and Verbal Behavior*, *21*, 55-69.

Clark, H.H. (1973). The language-as-fixed-effect fallacy: A critique of language statistics in psychological research. *Journal of Verbal Learning and Verbal Behavior*, *12*, 335-359.

Clark, H.H. (1976). Reply to Wike and Church. *Journal of Verbal Learning and Verbal Behavior*, *15*, 257-261.

Cohen, J. (1976). Random means random. *Journal of Verbal Learning and Verbal Behavior*, *15*, 261-262.

Coleman, E.B. (1964). Generalizing to a language population. *Psychological Reports*, *14*, 219-226.

Coleman, E.B. (1979). Generalization effects vs. random effects: Is $\sigma_{\pi L}^2$ a source of type 1 or type 2 error? *Journal of Verbal Learning and Verbal Behavior*, *18*, 243-256.

Collins, A.M., & Loftus, E.F. (1975). A spreading-activation theory of semantic processing. *Psychological Review*, *82*, 407-428.

Dagenbach, D., Horst, S., & Carr, T. H. (1990). Adding new information to semantic memory: How much learning is enough to produce automatic priming? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*, 581-591.

Davenport, J.M., & Webster, J.T. (1973). A comparison of some approximate *F*-tests. *Technometrics*, *15*, 779-789.

De Groot, A.M.B. (1980). *Mondelinge woordassociatienormen: 100 woordassociaties op 460 Nederlandse zelfstandige naamwoorden (Verbal word association norms: 100 word associations to 460 Dutch nouns)*. Lisse, The Netherlands: Swets & Zeitlinger.

De Groot, A.M.B. (1983). The range of automatic spreading activation in word priming. *Journal of Verbal Learning and Verbal Behavior*, *22*, 417-436.

De Groot, A.M.B., Thomassen, A.J.W.M., & Hudson, P.T.W. (1982). Associative facilitation of word recognition as measured from a neutral prime. *Memory and Cognition*, *10*, 358-370.

Den Heyer, K. (1986). Manipulating attention-induced priming in a lexical decision task by means of repeated prime-target presentations. *Journal of Memory and Language*, *25*, 19-42.

Den Heyer, K., Goring, A., & Dannenbring, G.L. (1985). Semantic priming and word repetition: The two effects are additive. *Journal of Memory and Language*, *24*, 699-716.

Dosher, B.A., & Rosedale, G. (1991). Judgments of semantic and episodic relatedness: Common time-course and failure of segregation. *Journal of Memory and Language*, *30*, 125-160.

Dunn, J.C., & Kirsner, K. (1988). Discovering functionally independent mental processes: the principle of reversed association. *Psychological Review*, *95*, 91-101.

Durgunoglu, A. Y., & Neely, J. H. (1987). On obtaining episodic priming in a lexical decision task following paired-associate learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *13*, 206-222.

Evett, L.J., & Humphreys, G.W. (1981). The use of abstract graphemic information in lexical access. *Quarterly Journal of Experimental Psychology*, *33*, 325-350.

Ferreira, F., & Clifton, C. (1986). The independence of syntactic processing. *Journal of Memory and Language*, *25*, 348-368.

Feustel, T.C., Shiffrin, R.M., & Salasoo, A. (1983). Episodic and lexical contributions to the repetition effect in word identification. *Journal of Experimental Psychology: General*, *112*, 309-346.

Fischler, I. (1977). Semantic facilitation without association in a lexical decision task. *Memory and Cognition*, *5*, 335-339.

Fischler, I., & Goodman, G.O. (1978). Latency of associative activation in memory. *Journal of Experimental Psychology: Human Perception and Performance*, *4*, 455-470.

Forster, K.I, & Davis, C. (1984). Repetition priming and frequency attenuation in lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *10*, 680-698.

Forster, K.I., & Dickinson, R.G. (1976). More on the language-as-fixed-effect fallacy: Monte Carlo estimates of error rates for F_1, F_2, F', and *min* F'. *Journal of Verbal Learning and Verbal Behavior*, *15*, 135-142.

Fowler, C.A., Wolford, G., Slade, R., & Tassinary, L. (1981). Lexical access with and without awareness. *Journal of Experimental Psychology: General*, *110*, 341-362.

Gillund, G., & Shiffrin, R. (1984). A retrieval model for both recognition and recall. *Psychological Review*, *19*, 1-65.

Glenberg, A.M. (1979). Component-levels theory of the effects of spacing of repetitions on recall and recognition. *Memory and Cognition*, *7*, 95-112.

Graf, P., & Schacter, D.L. (1985). Implicit and explicit memory for new associations in normal and amnesic subjects. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *11*, 501-518.

Haarmann, H.J., & Mesman, B. (1994). A new connectionist model of episodic and semantic priming. In preparation.

Herrmann, D.J., & Harwood, J.R. (1980). More evidence for the existence of separate semantic and episodic stores in long-term memory. *Journal of Experimental Psychology: Human Learning and Memory*, *6*, 467-478.

Hines, D., Czerwinski, M., Sawyer, P.K., & Dwyer, M. (1986). Automatic semantic priming: Effect of category exemplar level and word association level. *Journal of Experimental Psychology: Human Perception and Performance*, *12*, 370-379.

Hintzman, D.L. (1986). "Schema abstraction" in a multiple-trace memory model. *Psychological Review*, *93*, 411-428.

Hintzman, D.L., & Stern, L.D. (1978). Contextual variability and memory for frequency. *Journal of Experimental Psychology: Human Learning and Memory*, *4*, 539-549.

Hirshman, E., & Durante, R. (1992). Prime identification and semantic priming. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *18*, 255-265.

Hirst, W. (1984). Factual memory? *The Behavioral and Brain Sciences*, *7*, 241-242.

Hodgson, J.M. (1991). Informational constraints on pre-lexical priming. *Language and Cognitive Processes*, *6*, 169-205.

Holender, D. (1986). Semantic activation without conscious identification in dichotic listening, parafoveal vision, and visual masking: A survey and appraisal. *The Behavioral and Brain Sciences*, *9*, 1-66.

Howard, D.V., Fry, A.F., & Brune, C.M. (1991). Aging and memory for new associations: Direct versus indirect measures. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *17*, 779-792.

Humphreys, M.S., Bain, J.D., & Pike, R. (1989). Different ways to cue a coherent memory system: A theory for episodic, semantic and procedural tasks. *Psychological Review*, *96*, 208-233.

Jacoby, L.L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General*, *3*, 306-340.

Jacoby, L.L., & Witherspoon, D. (1982). Remembering without awareness. *Canadian*

Journal of Psychology, *36*, 300-324.

James, W. (1950). *The principles of psychology* (Vol. I) [authorized edition, first published by Henry Holt & Company in 1890]. New York: Dover Publications, Inc.

Keppel, G. (1976). Words as random variables. *Journal of Verbal Learning and Verbal Behavior*, *15*, 263-265.

Kinsbourne, M., & Wood, F. (1975). Short-term memory processes and the amnesic syndrome. In D. Deutsch and A.J. Deutsch (Eds.), *Short-term memory* (pp. 258-291). New York: Academic Press.

Kintsch, W. (1974). *The representation of meaning in memory*. Lawrence Erlbaum Associates.

Kirk, R.E. (1982). *Experimental design: procedures for the behavioral sciences*. Pacific Grove: Brooks/Cole Publishing Company.

Kolers, P.A., & Perkins, D.N. (1975). Spatial and ordinal components of form perceptions and literacy. *Cognitive Psychology*, *7*, 228-267.

Kolers, P.A., Palef, S.R., & Stelmach, L.B. (1980). Graphemic analysis underlying literacy. *Memory and Cognition*, *8*, 322-328.

Koriat, A. (1981). Semantic facilitation in lexical decision as a function of prime-target association. *Memory and Cognition*, *9*, 587-598.

Kucera, H., & Francis, W.N. (1967). *Computational analysis of present-day American English*. Providence, RI: Brown University Press.

Lauteslager, M., Schaap, T., & Schievels, D. (1986). *Schriftelijke woordassociatienormen voor 549 Nederlandse zelfstandige naamwoorden (Written word association norms of 549 Dutch nouns)*. Lisse: Swets & Zeitlinger.

Lupker, S.J. (1984). Semantic priming without association: A second look. *Journal of Verbal Learning and Verbal Behavior*, *23*, 709-733.

Marcel, A.J. (1983). Conscious and unconscious perception: Experiments on visual masking and word recognition. *Cognitive Psychology*, *15*, 197-237.

Marohn, K.M., Hochhaus, L. (1987). Semantic priming increases and repetition priming decreases apparent stimulus duration. *Journal of General Psychology*, *115*, 51-61.

McCloskey, M., & Santee, J. (1981). Notes, comments, and new findings. Are semantic memory and episodic memory distinct systems? *Journal of Experimental Psychology: Human Learning and Memory*, *7*, 66-71.

McKoon, G., & Ratcliff, R. (1979). Priming in episodic and semantic memory. *Journal of Verbal Learning and Verbal Behavior, 18*, 463-480.

McKoon, G., & Ratcliff, R. (1986). Automatic activation of episodic information in a semantic memory task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12*, 108-115.

McKoon, G., Ratcliff, R., & Dell, G.S. (1986). A critical evaluation of the semantic-episodic distinction. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12*, 295-306.

Mensink, G.J., Raaijmakers, J.G.W. (1988). A model for interference and forgetting. *Psychological Review, 95*, 434-455.

Mensink, G.J., & Raaijmakers, J.G.W. (1989). A model of contextual fluctuation. *Journal of Mathematical Psychology, 33*, 172-186.

Meyer, D., & Schvaneveldt, R. W. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology, 90*, 227-234.

Neely, J.H. (1977). Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited-capacity attention. *Journal of Experimental Psychology: General, 106*, 226-254.

Neely, J.H. (1989). Experimental dissociations and the episodic/semantic memory distinction. In: H.L. Roediger & F.I.M. Craik (Eds.), *Varieties of memory and consciousness: Essays in Honour of Endel Tulving* (pp. 229-270). Hillsdale, NJ: Erlbaum.

Neely, J.H. (1991). Semantic priming effects in visual word recognition: A selective review of current findings and theories. In: D. Besner & G. Humphreys (Eds.), *Basic processes in reading: Visual word recognition* (pp. 264-336). Hillsdale, NJ: Erlbaum.

Neely, J. H., & Durgunoglu, A. Y. (1985). Dissociative episodic and semantic priming effects in episodic recognition and lexical decision tasks. *Journal of Memory and Language, 24*, 466-489.

Norris, D. (1984). The effects of frequency, repetition and stimulus clarity in visual word recognition. *The Quarterly Journal of Experimental Psychology, 36A*, 507-518.

Potts, G.R., & Peters, S.B. (1985). Incorporation versus compartmentalization in memory for discourse. *Journal of Memory and Language, 24*, 107-118.

Potts, G.R., St. John, M.F., & Kirson, D. (1989). Incorporating new information into existing world knowledge. *Cognitive Psychology, 21*, 303-333.

Raaijmakers, J.G.W. (1984). *Psychologie van het geheugen (The psychology of memory).* Deventer: Van Loghum Slaterus.

Raaijmakers, J.G.W. (1993). The story of the two-store model: Past criticisms, current status, and future directions. In Meyer, D.E., & Kornblum, S. (Eds.), *Attention and Performance XIV: Synergies in Experimental Psychology, Artificial Intelligence, and Cognitive Neuroscience* (pp. 467-488). Cambridge, M.A.: MIT Press.

Raaijmakers, J.G.W., & Shiffrin, R.M. (1981a). Search of associative memory. *Psychological Review, 88*, 93-134.

Raaijmakers, J.G.W., & Shiffrin, R.M. (1981b). Order effects in recall. In: J.B. Long & A.D. Baddeley (Eds.), *Attention and Performance IX* (pp. 403-415). Hillsdale, N.J.: Erlbaum.

Ratclitff, R., & McKoon, G. (1988). A retrieval theory of priming. *Psychological Review, 95*, 385-408.

Rayner, K., Carlson, M., & Frazier, L. (1983). The interaction of syntax and semantics during sentence processing: Eye movements in the analysis of semantically biased sentences. *Journal of Verbal Learning and Verbal Behavior, 22*, 358-374.

Richardson-Klavehn, A., & Bjork, R.A. (1988). Measures of memory. *Annual Review of Psychology, 36*, 475-543.

Roediger, H.L. (1984). Does current evidence from dissociation experiments favor the episodic/semantic distinction? *The Behavioral and Brain Sciences, 7*, 252-254

Rouse, R.O., & Verinis, J.S. (1962). The effect of associative connections on the recognition of flashed words. *Journal of Verbal Learning and Verbal Behavior, 1*, 300-303.

Salasoo, A., Shiffrin, R. M., & Feustel, T. C. (1985). Building permanent memory codes: codification and repetition effects in word identification. *Journal of Experimental Psychology: General, 114*, 50-77.

Santa, J.L., Miller, J.J., & Shaw, M.L. (1979). Using quasi *F* to prevent alpha inflation due to stimulus variation. *Psychological Bulletin, 86*, 37-46.

Scarborough, D.L., Cortese, C., & Scarborough, H.S. (1977). Frequency and repetition effects in lexical memory. *Journal of Experimental Psychology: Human Perception and Performance, 3*, 1-17.

Schacter, D.L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory and Cognition, 13*, 501-518.

Schacter, D.L., & Graf, P. (1986). Effects of elaborative processing on implicit and explicit memory for new associations. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12*, 432-444.

Schwartz, B., & Reisberg, D. (1991). *Learning and memory*. New York: W.W. Norton & Company.

Seidenberg, M.S., Waters, G.S., Sanders, M., & Langer, P. (1984). Pre- and postlexical loci of contextual effects on word recognition. *Memory and Cognition, 12*, 315-328.

Shelton, J.R., & Martin, R.C. (1992). How semantic is automatic semantic priming? *Journal of Experimental Psychology: Learning, Memory and Cognition, 18*, 1191-1210.

Shiffrin, R.M, & Raaijmakers, J.G.W. (1992). The SAM retrieval model: A retrospective and prospective. In: A.F. Healy, S.M. Kosslyn & R.M. Shiffrin (Eds.), *From learning processes to cognitive processes: Essays in honor of William K. Estes, Volume 2* (pp. 69-86). Hillsdale, N.J.: Erlbaum.

Shoben, E.J., Wescourt, K.T., & Smith, E.E. (1978). Sentence verification, sentence recognition, and the semantic-episodic distinction. *Journal of Experimental Psychology: Humam Learning and Memory, 4*, 304-317.

Smith, J.E.K. (1976). The assuming-will-make-it-so fallacy. *Journal of Verbal Learning and Verbal Behavior, 15*, 262-263.

Smith, M.C., MacLeod, C.M., Bain, J.D., & Hoppe, R.B. (1989). Lexical decision as an indirect test of memory: Repetition priming and list-wide priming as a function of type of encoding. *Journal of Experimental Psychology: Learning, Memory and Cognition, 15*, 1109-1118.

Taraban, R., & McClelland, J.L. (1988). Constituent attachment and thematic role assignment in sentence processing: In fluences of content-based expectations. *Journal of Memory and Language, 27*, 597-632.

't Hooft, R. (1987). *Suomi-Hollanti sanakirja, Fins-Nederlands woordenboek (Finnish-Dutch dictionary)*. Gummerus Oy:n kirjapaino Jyväskylä.

Tulving, E. (1972). Episodic and semantic memory. In: E. Tulving, & W. Donaldson (Eds.), *Organization of Memory* (pp. 381-403). New York: Academic Press.

Tulving, E. (1983). *Elements of episodic memory*. New York: Oxford University Press.

Tulving, E. (1984). Precis of elements of episodic memory. *The Behavioral and Brain Sciences, 7*, 223-268.

Tulving, E. (1985). How many memory systems are there? *American Psychologist, 40*, 385-398.

Tulving, E. (1986). What kind of a hypothesis is the distinction between episodic and semantic memory? *Journal of Experimental Psychology: Learning, Memory and Cognition*, *12*, 307-311.

Tulving, E., & Schacter, D.L. (1990). Priming and human memory systems. *Science*, *247*, 301-306.

Tulving, E., Hayman, C.A.G., & MacDonald, C.A. (1991). Long-lasting perceptual priming and semantic learning in amnesia: A case experiment. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *17*, 595-617.

Uit den Boogaart, P.C. (1975). *Woordfrequenties in geschreven en gesproken Nederlands (Word frequencies in written and spoken Dutch)*. Utrecht: Oosthoek, Scheltema & Holkema.

Van Loon, W.A., & van Bekkum, I.J. (1991). *Woordassociatie lexicon (Word association lexicon)*. Amsterdam: Swets & Zeitlinger.

Van Winsum-Westra, M. (1990). *Spacing and repetition effects in human memory*. Unpublished doctoral dissertation, Nijmegen Institute for Cognition and Information, Nijmegen.

Watkins, M.J., & Kerkar, S.P. (1985). Recall of a twice-presented item without recall of either presentation: Generic memory for events. *Journal of Memory and Language*, *24*, 666-678.

Wickens, T.D., & Keppel, G. (1983). On the choice of design and of test statistic in the analysis of experiments with sampled materials. *Journal of Verbal Learning and Verbal Behavior*, 22, 296-309.

Wike, E.L., & Church, J.D. (1976). Comments on Clark's "The language-as-fixed-effects fallacy." *Journal of Verbal Learning and Verbal Behavior*, *15*, 249-255.

Wilding, J. (1986). Joint effects of semantic priming and repetition in a lexical decision task: Implications for a model of lexical access. *The Quarterly Journal of Experimental Psychology*, *38A*, 213-228.

Winer, B.J. (1971). *Statistical principles in experimental design*. New York: McGraw-Hill.

Wolters, G. (1984). Memory: Two systems or one system with many subsystems? *The Behavioral and Brain Sciences*, *7*, 256-257.

Chris Schrijnemakers werd op 21 oktober 1961 in de Capucijnenstraat te Maastricht geboren. Hij volgde de atheneum-A opleiding aan het Sint Maartenscollege te Maastricht, waar hij in mei 1980 zijn diploma behaalde.

In september van datzelfde jaar startte hij met zijn studie Psychologie aan de Katholieke Universiteit te Nijmegen. Hij behaalde zijn kandidaatsexamen in september 1983, waarna hij zijn studie vervolgde bij de Intervakgroep Sociale Gerontologie tot 1987. Vanaf 1986 studeerde hij ook aan de vakgroep Mathematische Psychologie en behaalde daar in februari 1989 zijn doctoraalexamen (Prof. Dr. E. Roskam). Tijdens zijn studie werkte hij regelmatig als studentassistent en schreef de syllabus *Methoden en technieken ten behoeve van psychodiagnostiek* en was mede-auteur van het rapport *Hulpbehoevendheid in het verzorgingshuis, deel III.*

In de periode van 1989-1993 was hij als assistent in opleiding in dienst van het Nijmeegs Instituut voor Cognitie en Informatie en gedetacheerd bij het Instituut voor Zintuigfysiologie TNO[1] te Soesterberg (Prof. Dr. J. Raaijmakers). In Soesterberg, Nijmegen, Maastricht en Leiden werd het onderzoek uitgevoerd dat in deze dissertatie beschreven staat. In Nijmegen gaf hij ook onderwijs in methoden en technieken van onderzoek aan derdejaars psychologiestudenten.

Thans is hij als tijdelijk onderzoeker verbonden aan de vakgroep Psychonomie van de Universiteit van Amsterdam.

[1] Tegenwoordig draagt het instituut de naam TNO Technische Menskunde.

Stellingen

1. In tegenstelling tot wat het geval is bij de vorming van een nieuwe woordcode is minimale repetitie zonder leerinstructie geen voldoende factor voor de vorming van een nieuwe code voor de semantische associatie tussen twee woorden.

   (Dit proefschrift).

2. De automatische activatie van episodische associaties in lexicale decisie en perceptuele identificatie duidt erop dat deze taken niet uitsluitend semantische geheugentaken zijn.

   (Dit proefschrift).

3. De facilitatie van lexicale decisietijden in Conditie 1 van het derde experiment van Dagenbach, Horst en Carr (1990) is geen semantische, maar episodische priming bij nieuw-geleerde associaties.

   (Dit proefschrift).

4. Episodische priming bij nieuw-geleerde en bestaande associaties is contextafhankelijk, met context gemanipuleerd als type computerscherm, letterfont, lettergrootte en letterkleur.

   (Dit proefschrift).

5. Het berekenen van *min F'* is geen geschikte statistische procedure indien men experimenteel voor itemvariantie gecontroleerd heeft.

   (Dit proefschrift).

6. Ten aanzien van spreidingseffecten in vrije reproduktietaken doet de Rehearsal theorie geformaliseerd als een buffermodel dezelfde predicties als de Consolidation theorie slechts en slechts dan als bij iedere presentatie van een nieuw item tijdens de opslagfase elk item tot dan toe aanwezig in de buffer vervangen kan worden door het nieuw-gepresenteerde item.

   (Schrijnemakers, J.M.C. (1989). *Repetition-, distribution- and spacing effects in free recall as described by the SAM model.* Ongepubliceerde afstudeerscriptie, vakgroep Mathematische Psychologie, Katholieke Universiteit Nijmegen).

7. Een bijna perfecte stabiliteitscoefficiënt bepaald bij een gedragsobservatieschaal is eerder een indicatie voor schending van de assumptie van experimentele onafhankelijkheid dan voor betrouwbaarheid van het meetinstrument.

   (Schrijnemakers, J.M.C. (1986). Onderzoeksstageverslag, Intervakgroep Sociale Gerontologie, Katholieke Universiteit Nijmegen).

8. In de 'appraisive' gebieden der psychologie biedt Gerrit Komrij's *Humeuren en temperamenten: Een encyclopedie van het gevoel* een interessant startpunt voor het formuleren van een domein-definitie voor toepassing in facet-design.

   (Broers, N. (1994). *Formalized theory of appraisive judgments.* Unpublished doctoral dissertation, Nijmegen Institute for Cognition and Information, Nijmegen).

9. De ik-figuur in Willem Brakmans *Een heiligverklaring* overwoog terecht of hij zich werkelijk maar één zondagmiddagvisite herinnerde of dat hij diverse middagen had laten samenvloeien.

   (Hintzman, D.L., & Stern, L.D. (1978). Contextual variability and memory for frequency. *Journal of Experimental Psychology: Human Learning and Memory, 4,* 539-549).

10. Veel Role-Playing Games lijden aan een te hoog Tolkiengehalte.

    (Jones, C. (1993). The problem with RPGs. *PC Review*, Issue 24, 24-25).

11. Het openbaar vervoer is behalve met mensen ook statisch geladen.

12. Gegeven het oorverdovende lawaai van het publiek waarin een pitcher zich in Major League Baseball concentreert op zijn wind-up en worp, is het nadrukkelijk om stilte vragen van een Grand Slam tennisser voor zijn service pure aanstellerij.

Stellingen behorende bij het proefschrift van Chris Schrijnemakers, 'The storage of newly learned information in semantic memory', Nijmegen 7 september 1994.